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Pollination (in Growing Alfalfa for Seed)

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Growing Alfalfa for Seed

Circular 135 - June 1955

AGRICULTURAL EXPERIMENT STATION

UTAH STATE AGRICULTURAL COLLEGE

in cooperation with the

UNITED STATES DEPARTMENT OF AGRICULTURE

Recommendations for Controlling Alfalfa Seed Insects and Mites

● **Alfalfa weevil.** Early in the spring when alfalfa shoots are 0.5 to 2 inches long, spray the field with 4 ounces of dieldrin or heptachlor or dust it with 5 ounces of heptachlor per acre.

● **Lygus bugs.** When alfalfa begins to bud, spray or dust with 1.5 to 2 pounds of DDT, 3 pounds of toxaphene, or 4 ounces of dieldrin per acre. A second treatment is usually desirable on first-crop seed and may be necessary on second-crop seed. Three to four weeks after the bud stage treatment, apply toxaphene at the rate of 1.5 pounds per acre as a spray or 2 pounds as a dust. Make this application after 7 p. m. or before 7 a. m. to protect bees.

● **Alfalfa seed chalcid.** Clean all seed promptly. Cultivate seed fields in the fall and spring to bury as many infested seeds as possible. Feed or destroy chaff stacks and screenings before May 1. Prevent volunteer alfalfa and burclover from forming pods. Avoid growing first- and second-crop seed in the same locality.

● **Grasshoppers.** When alfalfa is in bloom spray the field with 1.5 pounds of toxaphene per acre. Before plants bloom 1.5 to 2 ounces of aldrin, 0.5 to 1 pound of chlordane, 0.75 to 1 ounce of dieldrin, 3 to 4 ounces of heptachlor or 1 to 1.5 pounds of toxaphene may be used.

● **Mites.** Cultivate fields in fall and spring. In fields where mites have been troublesome, apply sulfur once or twice before the plants bloom (ten days apart) at the rate of 10 to 25 pounds per acre.

● **Aphids, armyworms, leafhoppers, thrips.** These pests are ordinarily controlled by the applications recommended for lygus bug control. Specific treatments for aphids and miscellaneous pests are given in the section on injurious insects and their control.

● **Observe the restrictions on feeding treated alfalfa and the cautions for personal safety given in this circular and on the insecticide containers.**

In Brief: This is the story

- Varieties:** A consistent demand is anticipated for seed of Ranger, Buffalo, Vernal, Atlantic, and Narragansett as these varieties are in the foundation seed program of the U. S. Department of Agriculture. Vernal should increase, Ladak should remain fairly constant, whereas Grimm should decrease in demand during the next few years.
- Culture:** Be a seed grower! Hay is another crop. Grow seed on thin stands. It is estimated that the optimum plant density will be obtained with plants about 12 inches apart in rows 24 to 36 inches apart. Control weeds.
- Insects:** Control harmful insects. Follow the recommendations given in this circular. Be on guard. Inspect fields for insect trouble at least once a week.
- Pollination:** See that seed fields have a good supply of bees. Wild bees are too scarce in most areas to give adequate pollination. Supplement their work with honey bees. From 3 to 6 colonies per acre are needed. Put them in large fields or adjacent to small fields. Work with your neighbors to eliminate competing sources of pollen and to share the costs and benefits of using honey bees for pollination.
- Harvesting:** Combine the crop from windrows or after chemical defoliation. Adjust the machine properly. Check the loss in the tailings with a sieve and continue adjustments until the loss is at a minimum. With most machines it will be more efficient to collect considerable chaff with the seed.

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Growing Alfalfa for Seed

Introduction

DURING THE last decade the growing of alfalfa seed has become a more stable farm enterprise. Expanded research on the subject has provided ways of eliminating many of the risks attributed to insect damage, poor pollination, and doubtful farming practices. As a result, the nation's annual production of seed

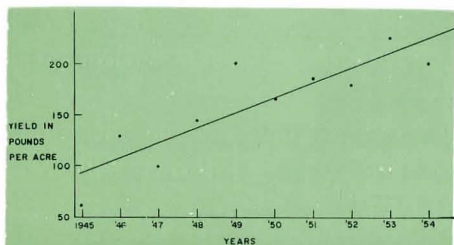


Fig. 1. Average yields of alfalfa in Utah from 1945 to 1954 inclusive as an example of increased yield in the seed growing states. Note that the yield per acre has more than doubled during that period.

has increased from less than 60 million to more than 150 million pounds. In other words, we have now achieved an adequate production of alfalfa seed (fig. 1). However, we are still far short of seed of improved varieties. Growers should switch to improved varieties and adopt all modern production practices as rapidly as possible in order to maintain a profitable enterprise in a competitive market.

Many growers can substantially increase their yields. Perhaps the most productive single step they can take is to produce seed exclusively on their seed acreage. It has long been the practice of seed growers to harvest either seed or hay from their alfalfa acreage depending upon which they thought, often at the last moment, was the more profitable move. With this attitude they have produced seed on stands which were planted for hay production. The result has been low seed yields.

This circular is intended to be a guide to growers that will enable them to plant, care for, and harvest alfalfa seed in accordance with the latest information that research has supplied.

Section I. Agronomic Practices

M. W. PEDERSEN AND D. R. McALLISTER

The Seed

Select a Variety in General Demand

THE FIRST consideration in producing alfalfa seed is to select a variety, the seed of which is in demand over a wide area of the United States, as most of the seed produced in the Intermountain Area is sold in the central or eastern states. For seed production, the United States is divided into the southern, central, and northern regions. The 40th parallel (south of Utah Lake) divides Utah into the central and northern regions, while the boundary between Utah and Arizona separates the southern and central zones (fig. 2). In order to produce certified seed of a variety outside of its region of adaptation, seed fields are limited to one generation and to stands not to exceed six years of age.

Varieties adapted to the northern region include Ranger, Grimm, Ladak, Narragansett, and Vernal, while Atlantic and Buffalo are adapted to the central zone. Varieties adapted to the southern region are not recommended for production in Utah.

Of the above-mentioned varieties, while Ladak is slightly resistant, only Ranger, Buffalo, and Vernal have suitable levels of resistance to bacterial wilt to avoid early loss of stands from this disease on wilt infested soils.

Seed yields of the different varieties are all satisfactory when conditions are favorable. The varieties have been under test at Logan for a number of years. As conditions for seed produc-



Fig. 2. Regions of adaptation for alfalfa seed production in the United States. In addition the region for Lahontan is bounded on the north by the state lines of Utah, Nevada, and California, on the east by the eastern boundary of Utah, and on the south by the 37° parallel

tion differ widely from one location to another, one cannot be sure that relative seed yields for varieties will be the same in other localities as they have been at Logan. Ladak yielded above and Buffalo below average. As seed was always taken from the first crop, Ladak may have been differentially favored. Narragansett yielded well, but has not been tested long enough to establish any superiority.

In breeding of new alfalfa varieties, breeders are now selecting for ability to produce high yields of seed. So we can expect the future varieties to be improved in this respect (fig. 3).

Of the varieties adapted to the northern region of the United States, those in greatest demand for hay production are Ranger, Narragansett, and Vernal, whereas Atlantic and Buffalo are most



Fig. 3. Alfalfa variety yield trial showing the regrowth after the first cutting. The hat is lying in a plot of Ladak; Lahontan is on the right

popular in the central region. If Vernal performs as expected, it may replace Ranger to a considerable extent in the northern part of the region of adaptation. As Vernal is the latest release, its market should expand faster than any of the other varieties in the next few years. These five varieties are included in the National Foundation Seed Program, and seed supplies are rapidly increasing. Grimm is losing its popularity because of its susceptibility to bacterial wilt. The demand for Ladak is not expected to change much. It is popular in short-season (one- and two-crop) areas because of a heavy first crop, and there is no new variety at present that can replace it.

It Pays to Produce Certified Seed

To maintain the genetic identity and purity of new and improved varieties it is essential that the seed be certified. Four classes of certified seed are recog-

nized: i.e. breeder, foundation, registered, and certified. Each class is one generation removed from the previous class (or seed produced from the previous class). Breeder seed is that developed by the breeder and is the source of the seed used for increasing and maintaining varieties. Foundation seed is produced from breeder seed. Registered seed is an extra generation increase which in the past has been necessary to expand the volume. Because of the rapid increase made possible by modern production practices this class may not be necessary for the increase of certain varieties in the future. In the case of Narragansett and Vernal the registered class of seed is not recognized. For these varieties the only increase beyond foundation seed is the certified class. Certified seed is the last generation advance permitted for alfalfa in a seed certification program and is the class intended for use in hay production.

With the development of the Founda-

tion Seed Program of the U. S. Department of Agriculture it has become possible to increase in relatively short periods of time the planting stocks needed to establish seed production fields. This, with expansion of certified seed programs in the states, has resulted in a constantly increasing production and supply of certified seed.

Advantages in Producing Certified Seed

There are certain regulations on the production of certified seed which are enforced by the state certifying agency. A charge is levied for this service, but the price differential in favor of certified seed has more than offset this fee. Contact the Crop Improvement Association for further information.

Selection of Site is Important

Historically, Millard and Uintah Counties have been the sites of the highest yields of alfalfa seed in Utah. This is possibly because these areas have good pollination that results from presence of large populations of wild bees and extensive pollen collection by honey bees. Seed can be grown successfully over most of the state, however, and is basically limited only by general conditions of soil and climate. Alfalfa has considerable drought tolerance, salt tolerance, and cold resistance and is thus remarkably adapted to a wide range of conditions. In northern Utah, however, seed production should not be attempted on dry land with less than 12 inches of rainfall or where the growing season

is less than 100 days. Moisture requirements will be higher farther south in the state and at lower elevations.

The expansion of alfalfa seed acreage into the dry land winter wheat area appears to be a sound practice, although moisture conditions are likely to limit yield. A yearly crop of about 100 pounds of alfalfa seed would appear to be as economical as 25 bushels of wheat every other year. In addition, the soil improvement by the alfalfa would increase subsequent yields of wheat. When new varieties are released, farmers on dry land usually have an advantage in meeting isolation requirements for seed certification.

Plant on a Firm Seedbed

Alfalfa generally should be planted at a depth of about one-half inch on a firm seedbed; however on light soils a slightly greater depth is preferred. To conserve moisture for the seed, the drill should have press wheels, or a cultipacker should be used. However, on heavy soils subject to crusting cultipacking after seeding may not be advisable.

Spring planting is usually the most satisfactory and should be early enough to take advantage of residual winter moisture and gentle spring rains. More stands are lost from drought than from frost in this area. Artificial watering later in the season is more likely to produce a crust. A companion crop of barley can be used on irrigated land

(except when growing foundation or registered seed), but is not recommended on dry land. On irrigated land late summer or early fall seeding is often

satisfactory, but the problem of keeping the soil moist enough to establish the seedlings is often difficult.

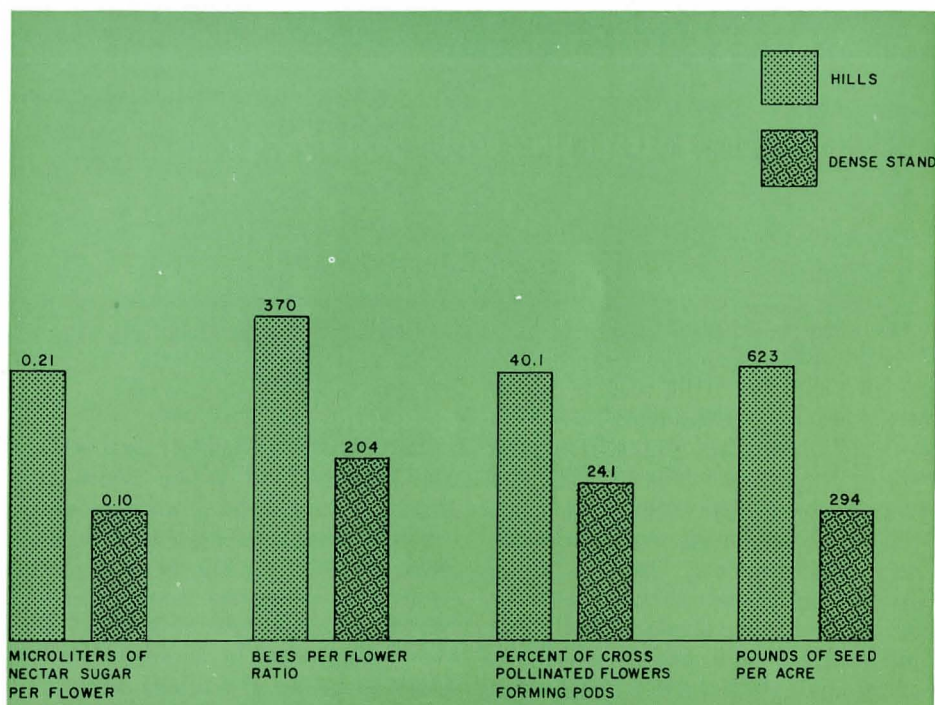


Fig. 4. Graph illustrating the deleterious effects of crowding of alfalfa plants on nectar secretion, honey bee visitation, ovary abortion, and seed production, Newton, Utah

Row Stands Versus Solid Stands

Crowding is harmful to seed production. In comparing 48-inch hills with dense hay-type stands at Newton, Utah, it was found that about twice as much seed was produced on the spaced plants as was produced on the hay-type stand. The low seed production on dense stands can be explained by low nectar production, unattractiveness to honey bees, and increased ovary abortion. The spaced plants had about twice as much nectar

per flower, twice as many bees per flower, and nearly twice as many of the cross-pollinated flowers formed pods as on the hay stand (fig. 4). It is obvious that the reproductive processes involving pollination and seed development are inhibited in dense stands.

Furthermore, optimum soil moisture is much harder to maintain with dense than with thinner stands. Consequently, the practice of using a hay stand for



Fig. 5. A light rate of seeding (1 pound per acre planted in 24-inch rows) is illustrated in the lower half of the picture. This rate produced 44 percent more seed than the heavy rate shown in the upper part of the picture (4 pounds per acre planted in 24-inch rows) over a 3-year period on both wet and dry soils

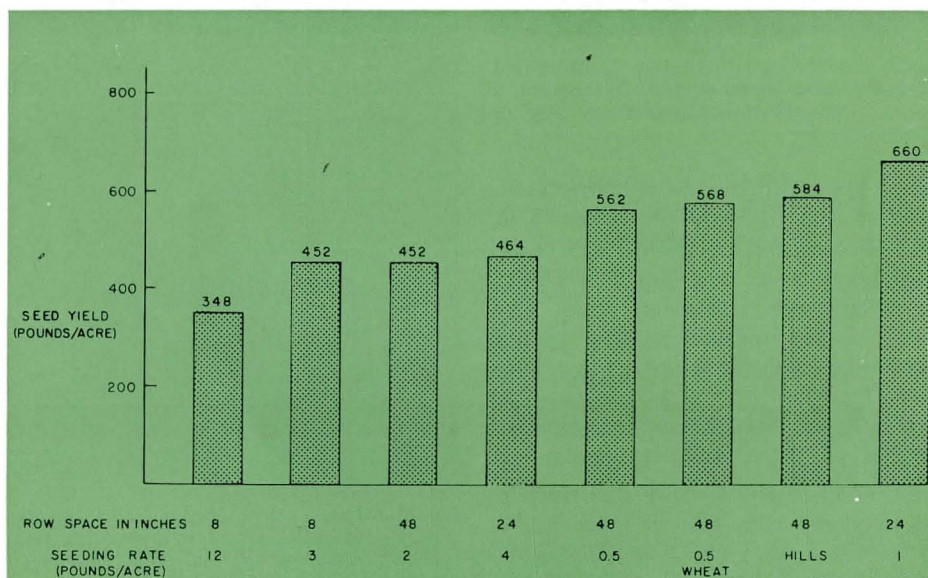


Fig. 6. Alfalfa seed production as influenced by row spacing, rate of seeding, and intercropping with winter wheat at Newton and Logan in 1953 (first full year of production)

seed production is not recommended. Available data indicate that for seed production alfalfa should be grown in rows not closer than 24 inches and at a

rate of seeding not higher than 1 pound per acre. The rate within the row (approximately 10 seeds per foot) should not be increased if a wider row space is

used (fig. 5). It is estimated that the optimum plant density would be obtained with plants at about 1-foot intervals in rows 24 to 36 inches apart. Results

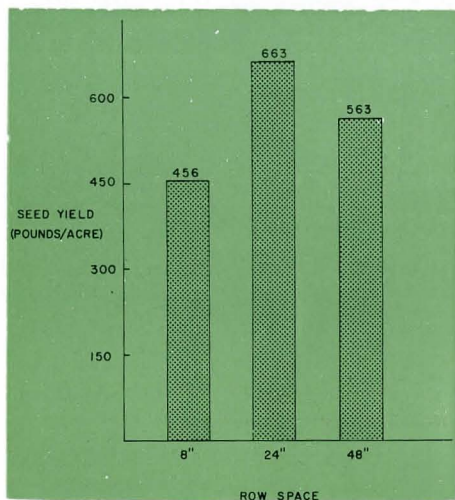


Fig. 7. Alfalfa seed production as influenced by the space between rows planted at a rate equivalent to one pound per acre in 24-inch rows

from experiments conducted since 1952 indicate that where alfalfa is grown in 48-inch rows and soil moisture is abundant wheat may be grown successfully as an intercrop in alternate years. The value of the wheat produced should more than offset the reduction in alfalfa seed (fig. 6).

The Evans Experimental Farm nursery, Logan, has been harvested for seed for three and the Newton nursery for two years. During this time the 24-inch rows have yielded an average of 147 percent of the 8-inch rows and 116 percent of the 48-inch rows (fig. 7). The low rate of seeding has yielded 145 percent of the high for the same period (fig. 8). These trends have been consistent. Average yields for the nurseries for this period have ranged from less than 100 pounds per acre (the year of

planting at the Evans Farm) to more than 470. The best treatment has consistently been the 24-inch rows seeded at a rate of 1 pound per acre which in 1953 yielded 675 pounds per acre on the Evans Farm.

Recent data indicate that a thinned stand produces as much or more seed as a stand originally planted at a light rate. On the basis of one experiment there appears to be a response to thinning that is greater than would be expected from merely creating a thin stand. Where 8-inch rows were thinned to 24-inch rows after the first crop year

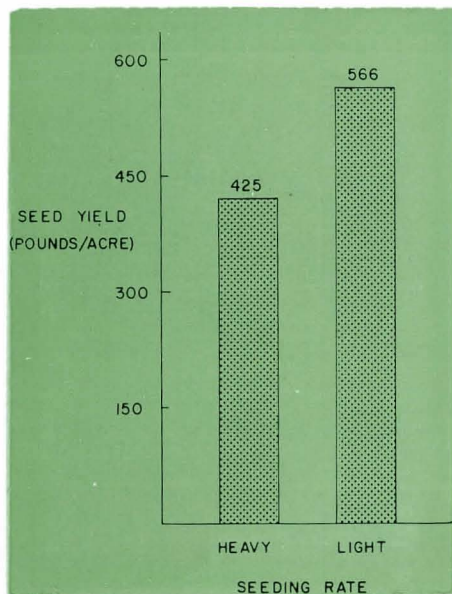


Fig. 8. Alfalfa seed production in 24 and 48 inch rows as influenced by a planting rate equivalent to one and four pounds per acre

the yield was significantly better than where 24-inch rows were planted in the first place. Some additional advantages of this method include:

- stands are easier to establish on problem soils,

- a hay crop can be taken in the year of seeding,
- the need for weed control, often a difficult problem the first year on spaced plantings, is minimized.
- farm drills are easier to set for a higher rate of seeding.

To thin a dense stand, two-thirds of the rows should be cut out so that the remaining rows are at least 24 inches apart. The remaining rows should then be cross thinned to cut out about two-thirds of the plants in the row. A single thinning operation is all that is required. Thinning will be simplified if done before the plants are too large.

Cultivation Needed in Seed Production

Where seed is grown in rows, cultivation is essential for weed control. There is also an apparent stimulation to the plant caused by loosening the soil. In a thinning experiment, it was concluded that a significant increase in yield above that attributed to thinning the stand was caused by the fall cultivation (3 to 4 inches deep) involved in cutting out the plants (fig. 9). Volunteering can be prevented by cultivating with a spring tooth, harrow, but should not be a problem unless there are gaps in the rows. Once established, a seed stand can be cultivated vigorously without damage.

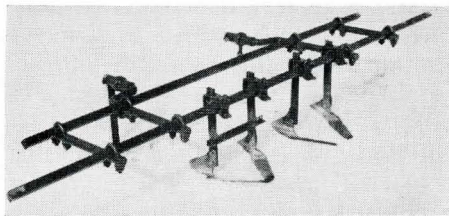


Fig. 9. Alfalfa thinning tool used on the experimental plots. The ends of the knives were welded together to insure that the plant roots were completely cut

Cultivation also destroys overwintering stages of mites, alfalfa seed chalcid, and other insects, as well as certain disease organisms.

Use of Hormones Still in Experimental Stage

The use of hormones to induce flowering and other physiological processes favorable to seed production shows some

promise. However, work in this field is entirely experimental at the present time.

Make Seed Crop Part of a Rotation

Short rotations are conducive to high yields. This applies to alfalfa seed as well as other crops grown in rotation with it. Evidence indicates that alfalfa seed yields decline annually. Seed fields

should be plowed out after no more than 5 or 6 years. A shorter rotation might be advisable where stands are easy to establish.

First Crop Best Under Most Conditions

In northern Utah more seed can be produced from the first growth than from the second. In addition, with first-crop seed there is less danger of partial or complete loss because of early frost. In a large seed district such as the Delta tract of Millard County, Utah, individual growers may profit materially by shifting from second-crop to first-crop seed production. However, unless the available supply of honey bees could be increased, a major trend to first-crop seed would seriously reduce the number of pollinators per acre of bloom. In some areas seed production may be increased by managing the alfalfa so that it blossoms during the time of greatest wild bee activity.

While specific cost analyses are not available it is believed that the specialized seed grower will make more profit from first crop seed than second in a relatively short growing season. It is recognized, however, that livestock interests and the relative price of hay and seed may favor the first crop for hay in some cases. This is particularly true in alkali bee areas where the best pollination is obtained in late July and early August.

Early spring grazing is useful in areas where only a short delay in growth of the crop is needed to time the bloom with alkali bees. The same method is applicable to areas where late spring frosts occur.

Soil Moisture and Fertility Must be Considered

Seed production is benefited by large, vigorously growing plants. However, excessive moisture on fertile soil seems to produce a vegetative rather than a reproductive type of growth characterized by excessive early lodging, delayed and prolonged flowering, and poor nectar production. Some of the disadvantages of this type of growth include:

- poor environment for pod and seed development under dense, lodged vegetation,
- unattractiveness to bees, especially pollen collectors,
- a long period of bloom requiring extended protection from lygus bugs and other pests,

- greater damage from leaf and stem diseases,
- greater danger of frost damage to immature seed, and
- increased difficulties in harvesting.

For soils that hold the moisture well, heavy irrigation no later than the early bud stage is likely to be adequate for the production of a seed crop. If moisture stress increases gradually as harvest approaches, the seed will ripen evenly and harvesting will be facilitated. After flowering commences, only enough water should be applied to keep the plants in a healthy condition.

Irrigation would appear to be simplified on spaced plants as there is a great-

er range of available soil moisture satisfactory for seed production. In areas where excessive soil moisture cannot be prevented, well-spaced plantings may succeed where solid plantings fail.

Evidence indicates that seed yields will increase in proportion to plant growth up to a certain point. In terms of chaff yield this point is 2.5 to 3 tons an acre if the stand is planted in rows at a light rate. More plant growth than this will reduce seed yields. To the casual observer a stand of this type during the

peak of bloom will appear much like a hay stand.

If a phosphate deficiency is suspected, laboratory tests should be made to determine the need. A strip test through the field is a good way to confirm a suspected deficiency. There are no known deficiencies of other elements for alfalfa seed production in Utah. For example, in a test at the Evans Farm no response in forage or seed was obtained from applications of nitrogen, phosphorus, boron, zinc, copper, or manganese.

Inoculation Usually not Needed

The soils of this area generally appear to be well supplied with the proper Rhizobia bacteria. However, if there is

any question about the presence of the bacteria, seed should be inoculated as the process is simple and inexpensive.

Seed Treatment not Necessary under Most Conditions

Although greenhouse tests show a response from fungicide treatment that is especially marked on summer-fallowed soil, the same response has not been demonstrated in Utah under field conditions. While seed treatment is of ques-

tionable value there may be merit in treating when planting expensive seed at light rates, or when conditions for germination and emergence are not considered good.

Careful Harvesting Saves Seed

Alfalfa can be threshed either in a stationary machine or a combine. If a combine is used, the crop can be harvested standing or it can be mowed and picked up from windrows. Local conditions, available machinery, labor, and experience will largely determine the method to be used. In general, the loss from shattering is proportional to the amount of handling. Seed crops should be cut when about three-fourths of the pods have darkened, and should be handled as little as possible to avoid

shattering. Cutting, windrowing, cocking, and other forms of handling before the growth is fed into the harvester should be performed early in the day before the vegetation becomes brittle. (On the other hand, the pods should be tested for toughness before the actual threshing begins.) Under Utah conditions it is usually at least 10 a. m. before the pods are sufficiently brittle for effective threshing.

Windrowing can be done with a curler or a windrow-swather. A curler



Fig. 10. Combining from the windrow in Millard County. This method is at a disadvantage where winds may disturb windrows

is satisfactory on a uniform growth that is not lodged and matted. Windrows tend to be uneven if a curler is used on a tangled growth (fig. 10). The windrow-swather has been used satisfactorily on all types of stands and the swath is less subject to wind damage.

Direct combining following a defoliation spray is a relatively new method of harvesting and is rapidly gaining in popularity. Harvesting in this way is accomplished with a minimum of labor and is especially advantageous where winds may disturb windrows (fig. 11). A common defoliation treatment, when applied by aircraft, is 1 quart of desiccant (dinitro product of the Dow- or Sinox-general type) in 10 gallons of diesel oil per acre applied several days prior to combining. When applied by a ground rig, water should be added so that 25 to 60 gallons of the resulting emulsion are applied per acre. A double application using 1 quart of desiccant to 8 gallons of oil for each

application has been used satisfactorily on a heavy growth. It is best not to treat a larger acreage than can be promptly combined as increased shattering may occur if the treated foliage is not combined within a few days after treatment. The treatment works best on mature, open stands that are not lodged. In addition, desiccation is more rapid at high temperatures. *Because some desiccants contain toxic ingredients, it is important that the manufacturer's recommendations on feeding treated alfalfa forage to livestock be followed closely.*

Fields infested with dodder are difficult to combine directly because dodder dries out more slowly than alfalfa. The effect of moist dodder is to slow down the machine and carry alfalfa seed out in the tailings.

Proper operation of the thresher is important if seed losses are to be held to a minimum. Such factors as wind blowing through the machine, type and

speed of reel, tilting caused by uneven ground, high moisture content of foliage, excessive ground speed of the combine, and improper adjustment of the machine may all contribute to seed losses. In addition, seed can leak from the machine at different places. The feeding mechanism, cleaning shoe, and elevators are frequent sources of leakage.

Proper machine adjustment varies according to the make, field conditions, and operator. In a recent study in California it was found that high cylinder speed was damaging the seed and reducing germination. This difficulty has not been serious elsewhere. A cylinder clearance of $3/16$ inch is usually recommended. Most machines are equipped with a shoe having an adjustable lip chaffer and round hole ($1/10$ inch) screen. The chaffer should be opened about $1/2$ inch for alfalfa seed threshing. The capacity of the shoe is the limiting factor in threshing alfalfa with the combine because of the heavy proportion of chaff. Use a "ground-powered" special reel if one is

needed and adjust so that the peripheral speed is about 10 percent greater than the forward speed of the combine.

When the volume to be handled is large, the seed lost through the combine is likely to increase in proportion to the forward speed of the machine. To reduce this loss some operators have modified their machines so that the forward speed is less than 1 mile per hour. Seed losses may be checked by following the combine while in operation and collecting tailings as they leave the machine on a sieve with a solid bottom pan underneath. Often times proper machine adjustment to hold down seed losses will result in collection of considerable chaff with the seed. This should not cause alarm as such inert matter can best be removed later in the cleaning plant.

Defoliation followed by direct combining was compared with windrowing in a recent test at the laboratory. Threshing was done with an all-crop harvester equipped with a pickup reel. Yields from both methods were almost iden-

Fig. 11. Combining defoliated alfalfa in Millard County, Utah. This is a method rapidly gaining in popularity throughout the country



tical. As a general rule, however, one would expect a higher recovery on a defoliated stand because

- the combine feeds more evenly,

- the straw does not break up as much and overload the shoe, and
- there is less handling of the crop.

Weeds Should be Controlled

When alfalfa is seeded at light rates for seed production, the usual annual weeds are more difficult to control than when heavy rates are used as for hay. Mowing and cultivation usually control annual weeds the year of seeding with no appreciable stand reduction. Cultivation in subsequent years, accom-

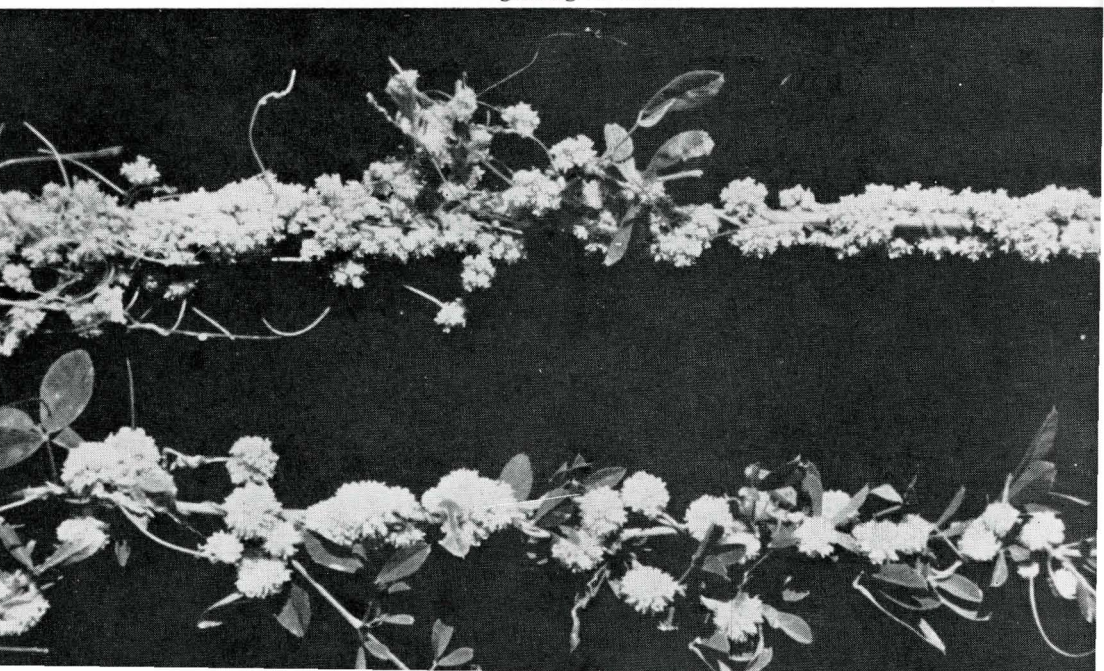
panied by hand roguing, is usually all that is required. Chemicals may be used to advantage in problem cases, especially if excessive hand weeding is to be required. Consult the Agricultural Experiment Station or your county agent for the latest information.

Dodder Serious Problem in Seed Alfalfa

Dodder is a serious threat to the alfalfa seed industry in Utah (fig. 12). Growing seed continuously and using long rotations are contributing to the dodder problem. Short rotations and careful field policing are the essential steps in dodder control. Extreme vigi-

lance throughout the life of the stand is needed to control dodder as there are many sources of infestation. Dodder-seed can enter a field in contaminated seed, unclean equipment, irrigation water, wind, rain, birds, and livestock. The first precaution is to plant dodder-

Fig. 12. Big (*Cuscuta indecora*) (top) and small (*C. approximata*) (bottom) seeded dodder growing on alfalfa



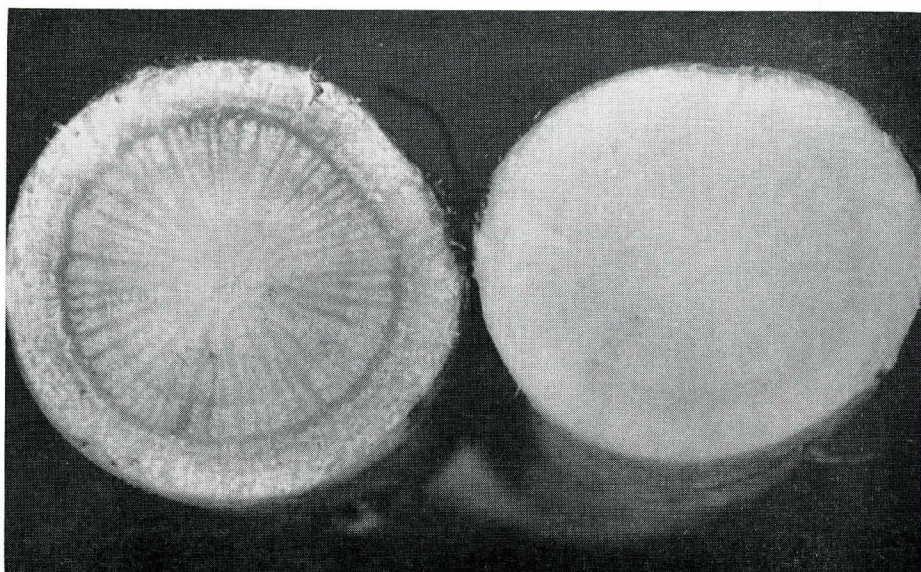


Fig. 13. An alfalfa root infected with bacterial wilt (left) compared to a healthy specimen (right)

free seed. Fields should be patrolled regularly to locate isolated patches of dodder. The patches found should be sprayed with an aromatic weed oil or a general dinitro fortified fuel oil-water emulsion. If seed has formed, cut and burn on the spot. A conditional recommendation for chemical control of dodder is to apply CIPC (isopropyl N-3-chlorophenyl carbamate) at the rate of

about 6 to 9 pounds per acre in 40 gallons of water just as growth of alfalfa starts in the spring. The cost is estimated to be about 15 dollars per acre. Results to date have been somewhat variable. Apparently effectiveness of the spray is modified by rainfall and growing conditions following application. Certain annual weeds are controlled with the same application.

Diseases and Nematodes Need Consideration

Bacterial Wilt Controlled with Resistant Varieties

With bacterial wilt (*Corynebacterium insidiosum*) the vascular system of the plant becomes plugged with bacterial growth which causes stunting, wilting,

and eventual death of the plant. Bacterial wilt causes thinning of the stand (fig. 13) and reduction in hay fields starting about the third year on irrigated land. The only control is to plant resistant varieties such as Ranger, Buffalo, or Vernal.



Fig. 14. Alfalfa stems infected with bacterial stem blight on the left compared to a healthy stem on the right

Bacterial Stem Blight a Disease of First Crop

Bacterial stem blight (*Pseudomonas medicaginis*) is a disease of the first crop. Frost damage opens avenues for infection of the stems and, therefore, the disease is more serious in years of late or severe frosts. Water-soaked lesions that later turn dark occur on the stems and leaves, and growth is

stunted. Severely infected growth will not produce seed well. Mowing the first crop for hay removes the damaged growth. The next cutting is not likely to be infected. Southern types of alfalfa are more susceptible than northern because of their early spring growth (fig. 14).

Yellow Leaf Blotch Often Serious in Seed Alfalfa

Yellow leaf blotch (*Pseudopeziza jonesii*) is primarily a disease of the leaves causing necrotic lesions with marginal yellowing and later discoloration. On stands cut for hay this disease is not ordinarily a problem because the hay is cut before the disease develops to serious proportions. However, certain seed areas in northern Utah are frequently partially to completely defoliated by the yellow leaf blotch organism.

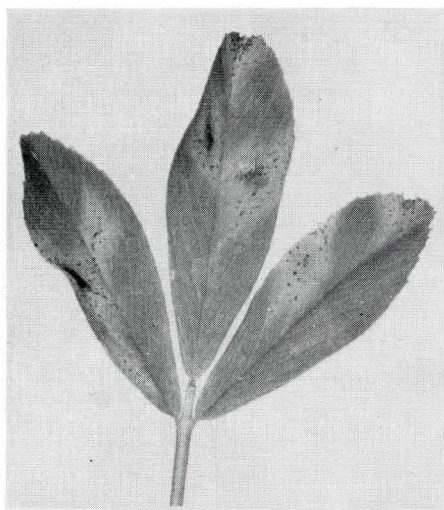


Fig. 15. Yellow leaf blotch on alfalfa in an early stage of the disease. When growing alfalfa for seed in the northern part of Utah this disease is the cause of loss in productivity in some years

At the Evans Experimental Farm, Ladak, Grimm, Vernal, and Narragansett have been damaged less by the blotch organism than Ranger, Buffalo, and Atlantic. In the northern part of the state, where blotch is often serious, the less susceptible varieties should have an advantage in seed production (fig. 15).

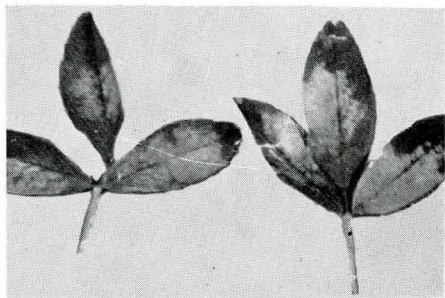


Fig. 16. Downy mildew is a cause of small but persistent losses. Seedling stands are often badly damaged by this disease

Downy Mildew Causes Small Losses

Downy mildew (*Peronospora trifoliorum*) occurs primarily in the northern part of Utah where a small but persistent loss occurs. Infected leaves appear light green in irregular areas (fig. 16) becoming yellowish later. The gray, downy mycelium and spores of the fungus can be observed on the underside of the leaf. Some alfalfa plants are resistant to the disease and plant breeders should be able eventually to control the loss by breeding.

Crown Wart May Cause Some Damage

Warty, cancerlike white galls are formed by this fungus (*Urophlyctis alfalfae*) on bud primordia on the crown of the plant. These galls are evident in the spring but disintegrate by mid-summer. Damage and loss from the disease are difficult to appraise (fig. 17).

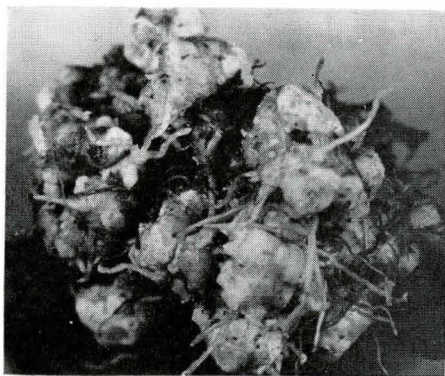
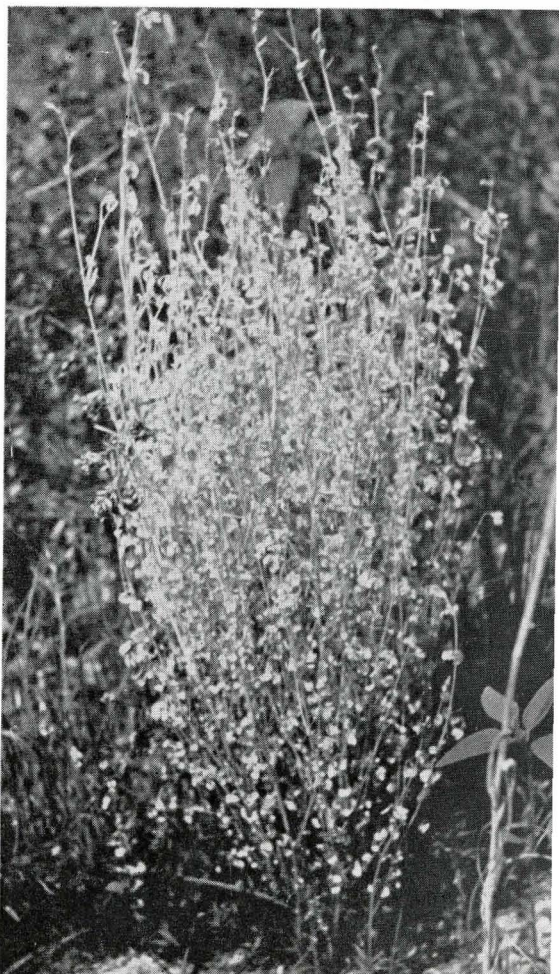


Fig. 17. Crown wart will be recognized by warty galls at the crown base of the alfalfa plants in the spring

Fig. 18. An alfalfa plant in a late stage of infection by the witches' broom virus photographed in the Uinta Basin where a heavy infestation recently occurred



No Control Measures Developed for Witches' Broom

Witches' broom is a virus disease of alfalfa and certain other legumes that causes proliferation of stems with stunting, yellowing, and eventual death of



Fig. 19. White spot, a physiological disturbance caused by unbalanced air and water conditions in the soil

the plant. Leafhoppers (*Scaphytopuia* spp.) transmit the virus from plant to plant. Sporadic outbreaks and natural recession have characterized this disease over the past 20 years. At the present time witches' broom occurs in Washington, the Yuma-Mesa area in Arizona, and the Uinta Basin in Utah. Control measures, other than to plow all alfalfa in an infested area, have not been developed (fig. 18).

White Spot Is a Physiological Disturbance

A physiological disturbance known as white spot often occurs in alfalfa when irrigation or rainfall follows a droughty period. This condition is expressed in

leaf lesions which range from minute necrotic flecks to large white spots. If the disease occurs in serious proportions the crop should be cut for hay. A slight occurrence should not be considered serious as the plants will outgrow the condition (fig. 19).

Stem Nematode Severe in Some Areas

The stem nematode (*Ditylenchus dipsaci*) a microscopic eel-like organism, is present on most irrigated land in the state. Severe infestations have long

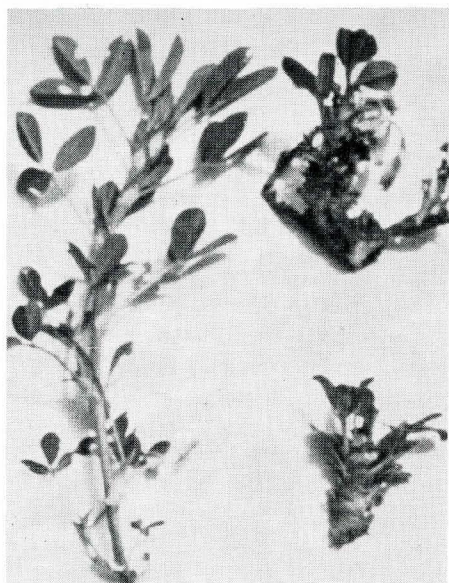


Fig. 20. Alfalfa stems infected with the stem nematode on the right compared to a healthy stem on the left. Infected stems are stunted and swollen

occurred in the Salt Lake Valley. Cold, wet weather in the spring promotes the damage by the organism. Infested stem buds are dwarfed, swollen, and usually fail to elongate. Infected plants eventually die (fig. 20).

The variety Nemastan is resistant to the stem nematode but is a low forage

and seed producer and susceptible to foliar diseases. Lahontan, a bacterial wilt and stem-nematode resistant variety developed by the U. S. Department of Agriculture at the Nevada Agricultural Experiment Station, promises to be an improvement over Nemastan.

Lahontan is presently recommended where nematodes are troublesome in Nevada and California. It is still being tested in Utah. Crop rotation also has value as a control measure. The fields should be kept free of alfalfa and clover plants for at least 2 or 3 years.

Section II. Injurious Insects and Mites and Their Control

BY F. V. LIEBERMAN AND G. F. KNOWLTON

Lygus Bugs Most Damaging Pest of Alfalfa Seed

Description and Injury

IN THE WEST lygus bugs (principally *Lygus elisus* and *L. hesperus*) are the most damaging pests of seed alfalfa. Both adults (fig. 21) and nymphs (fig. 22) feed on the plants. The adults are about $\frac{3}{16}$ inch long and half as wide. Their body color varies from pale green to reddish or dark brown. The newly hatched nymphs are difficult to see with the naked eye, but fifth-stage nymphs, although wing-

less, become nearly as large as adults. Color of the nymphs varies from yellowish to bluish green.

The mouth parts of these bugs are designed for piercing and sucking, and are encased in a long beak. The bugs draw out the plant juices for food. In addition to the mechanical injuries to the plant tissues which thus result, a local injury also develops from the injection of saliva into the punctures. These bugs prefer to feed on the reproductive parts of plants, and the

Fig. 21. Adult lygus bug

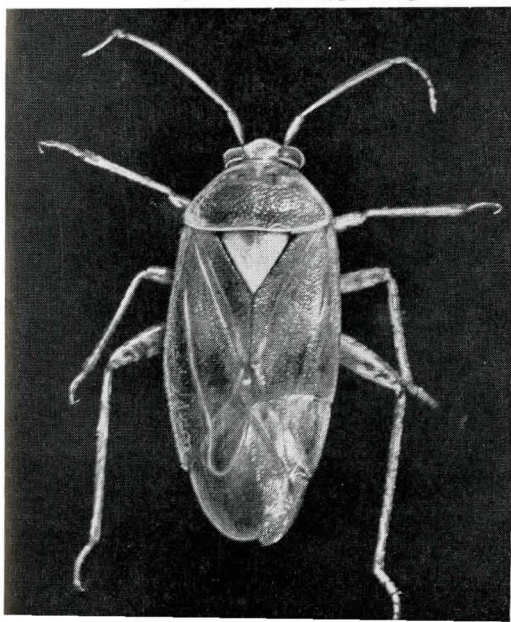


Fig. 22. Lygus bug nymph

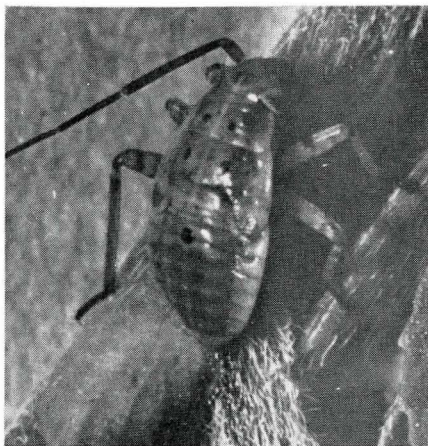




Fig. 23. Lygus-damaged alfalfa buds (left) and normal alfalfa buds and flowers

nymphs are much more destructive than the adults.

The greatest damage by lygus bugs to a crop of seed alfalfa generally occurs to the buds (fig. 23). Two to five days after being fed on, buds will die and bleach. If the infestation of lygus nymphs is heavy during the bud stage, total destruction of the buds may result and flowering will consequently be prevented. When damage is severe, the field assumes a grayish cast.

When flowering is not prevented, the bugs also feed on the flowers and cause them to drop. However, not all flower fall is attributable to lygus bug injury. Like many other plants, alfalfa develops more flowers than can be retained by a healthy plant and a normal flower fall always occurs. Furthermore, when pollination is deficient, flower fall is correspondingly greater.

Lygus bugs present in the field after pods form will feed on the immature seeds. Injured seeds shrivel and turn brown (fig. 24). When lygus bugs are abundant in the field during this period, a high percentage of seed can be destroyed.

Growth of the alfalfa is also affected by lygus bug feeding. Length of stems is reduced, generally in proportion to the intensity of the bug infestation. Stems become excessively branched with short internodes, and frequently the leaves become more numerous, smaller, and distorted.

Life History and Habits

Three or four generations of lygus bugs are produced each year in Utah's seed areas, each generation requiring 6 to 7 weeks for its complete development.

These bugs thrive on a wide range of both cultivated and uncultivated plants, and throughout the season the adults fly freely from host to host and from farm to farm.

Lygus bugs spend the winter as adults in the shelter of debris, litter, and dormant plant cover on the ground. Their activity begins in the spring as soon as temperatures are favorable.

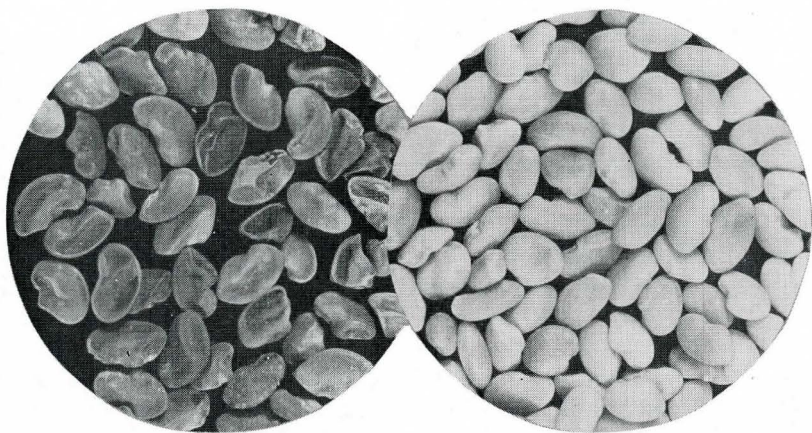


Fig. 24. Lygus-damaged alfalfa seed on left, normal seed on right

They immediately seek the most attractive plants and begin to feed and breed. Usually the first plants infested in the spring are common early flowering weeds, such as flixweed or tansymustard (*Descurainia sophia*), whitetop (*Cardaria draba*), and peppergrass (*Lepidium* spp.). These early weeds serve to expand the population of lygus bugs in a cultivated area, for on these plants nymphs often become full grown and change to adults before alfalfa begins to bud.

Infestation of alfalfa in the early spring is negligible, but as the first crop grows it becomes more and more attractive. Lygus adults in the fields gradually increase in numbers as the growth approaches the bud stage. The normal population of adults that infests an alfalfa field at this time is small, and from the practical viewpoint their damage to the plants is usually of minor

consequence. Nevertheless, the adults lay many eggs, inserting them singly into the tissues of the plants and placing most of them in the top 3 inches of the growth.

Hatching of eggs, which takes place in about 13 days, begins to occur in volume about the time the alfalfa develops buds. Lygus nymphs quickly become abundant on the plants. Because they occur in large numbers and feed constantly to provide their food requirements for growth, the nymphs cause most of the damage to seed alfalfa. The average time required for nymphs to complete their growth is 3 weeks, during which time they can destroy the crop.

When full grown, the nymphs change to adults, which ordinarily fly to fresh host plants and soon start another generation by laying eggs. These new adults that mature on first-crop alfalfa usually seek attractive second-crop al-

falfa or such weeds as smotherweed (*Bassia hyssopifolia*), Russian-thistle, (*Salsola kali*), povertyweed (*Iva axillaris*), or saltbush (*Atriplex* spp.), which flower in midsummer.

Development of the lygus bug population on second-crop alfalfa is similar but somewhat more rapid than that on first crop. Adults lay their eggs in fresh stems, and when the alfalfa reaches the bud stage the eggs hatch in large numbers. Nymphs complete their growth in about 3 weeks, and again most of the adults fly away to more attractive host plants, which include third-crop alfalfa as well as smotherweed, rabbit-brush (*Chrysothamnus nauseosus*), and other wild plants that flower late in the season. As fall approaches, egg laying gradually ceases and most of the late nymphs mature. The adults remain active as long as temperatures permit, gradually confining themselves to the protection of winter cover.

Naturally, the extent to which first- and second-crop seed, as well as seed and hay crops, are intermixed in a locality greatly influences the migration of lygus bugs from field to field. The more uniform the cropping practices of a neighborhood the easier becomes the

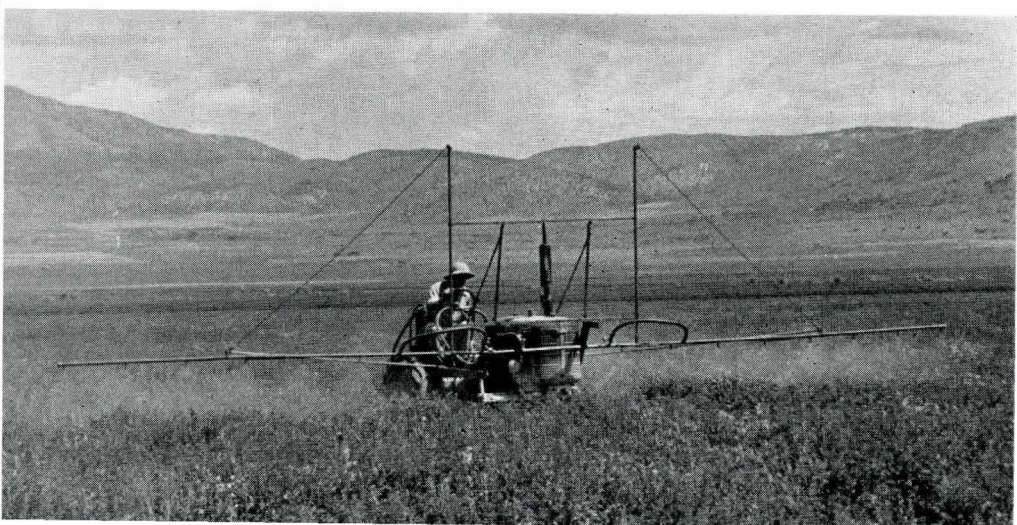
lygus bug control problem of the individual grower. The untimely cutting of first-crop hay on acreage adjoining first-crop seed often results in heavy reinfestation of the seed fields.

Control

Whether seed is grown from the first or second crop of alfalfa, the hatching of lygus nymphs in important numbers does not begin until the plants have started to bud. Applications of insecticides for lygus bug control before this time are therefore usually unnecessary. However, promptness in making an insecticide treatment when budding begins is all important. Delay of even a few days usually curtails the seed yield. The best plan is to watch the plants carefully and apply a recommended insecticide as soon as the first buds appear, even if only a few lygus bugs are seen in the acreage.

DDT was the first insecticide recommended for controlling lygus bugs. Generally speaking, it is still the best to use for this purpose. It can be applied as either dust or spray and with either ground rig (fig. 25) or aircraft. When dust is selected, not less than 20 pounds of 10-percent DDT per acre

Fig. 25. Applying the bud stage treatment for controlling lygus bugs



should be applied. A water emulsion spray which delivers 1.5 to 2 pounds of actual DDT per acre is equally satisfactory for ground application. Excellent results can be obtained with as little as 6 gallons of mixed spray per acre applied with low-pressure sprayers. Sprays ap-

this 3-week period. The greater the dosage of DDT applied, the quicker these adults were killed, the fewer eggs they laid, and the fewer nymphs later appeared on the plants. Thus, another application while the plants are blooming can often be avoided by using a relatively high dosage of DDT while the plants are budding.

In recent years growers in southwestern United States have encountered difficulty in controlling lygus bugs with DDT because this insecticide is less effective when high temperatures prevail. No experimental evidence has been obtained that DDT is not just as effective in the Rocky Mountain region as when first tried. However, should DDT decrease in effectiveness toxaphene may be substituted for it in the bud-stage application. Toxaphene at the rate of 3 pounds per acre, as either dust or spray, will give as good control of lygus bugs as the recommended dosages of DDT. Another insecticide that will give equally good lygus bug control is dieldrin, but special care should be taken to apply it before the alfalfa starts blooming, as it is very toxic to bees. Apply dieldrin in the early bud stage at the rate of 4 ounces per acre. Seventeen pounds of a 1.5-percent dust or 1.5 pints of emulsifiable liquid containing 1.5 pounds of dieldrin per gallon will provide this dosage.

When the first growth is used for seed, a second application is usually advisable. This should be made during the flowering period, from 3 to 4 weeks after the bud-stage treatment. Apply toxaphene as either dust or spray, but only when bees are not visiting the flowers. Generally speaking, toxaphene will not harm bees if applied between 7 p. m. and 7 a. m. A spray should contain 1.5 pounds of toxaphene per acre,

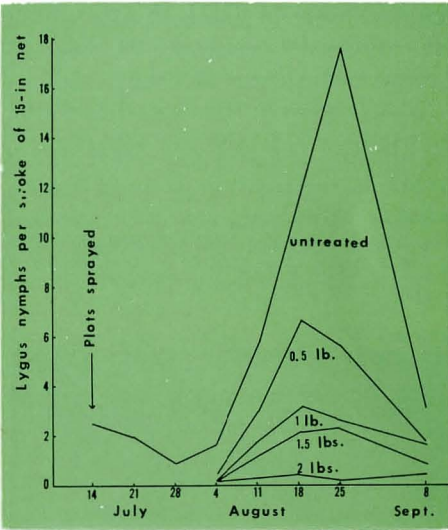


Fig. 26. Control of lygus nymphs by different dosages of DDT applied as water emulsion spray to plants in the bud stage of development

plied by aircraft should contain the same amount of DDT, but diesel fuel is recommended for dilution in place of water. Satisfactory results by air can be obtained with 2 gallons of mixed spray per acre.

It is important to use not less than the amount of DDT specified. The difference in control obtained by applying 0.5, 1, 1.5, and 2 pounds of DDT per acre in a water emulsion spray to duplicated plots of alfalfa in bud in the same field is shown in fig. 26. All four dosages of DDT eliminated lygus nymphs from the field for 3 weeks. Reinfestation by adults occurred during



Fig. 27. Alfalfa weevil adult

and a dust, 2 pounds per acre. If only lygus bugs need controlling at this time, satisfactory results can be obtained with DDT without killing bees, provided it is applied as a spray when bees are not in the field and at the rate of 0.5 pound of DDT per acre. DDT dust or higher dosage of DDT in spray form are too toxic for bees to use on alfalfa in bloom even when applied at night.

Many growers still use the second growth for seed production after removal

Fig. 28. Eggs of the alfalfa weevil laid in a green stem, upper part of picture, in a dry stem in the lower part of picture

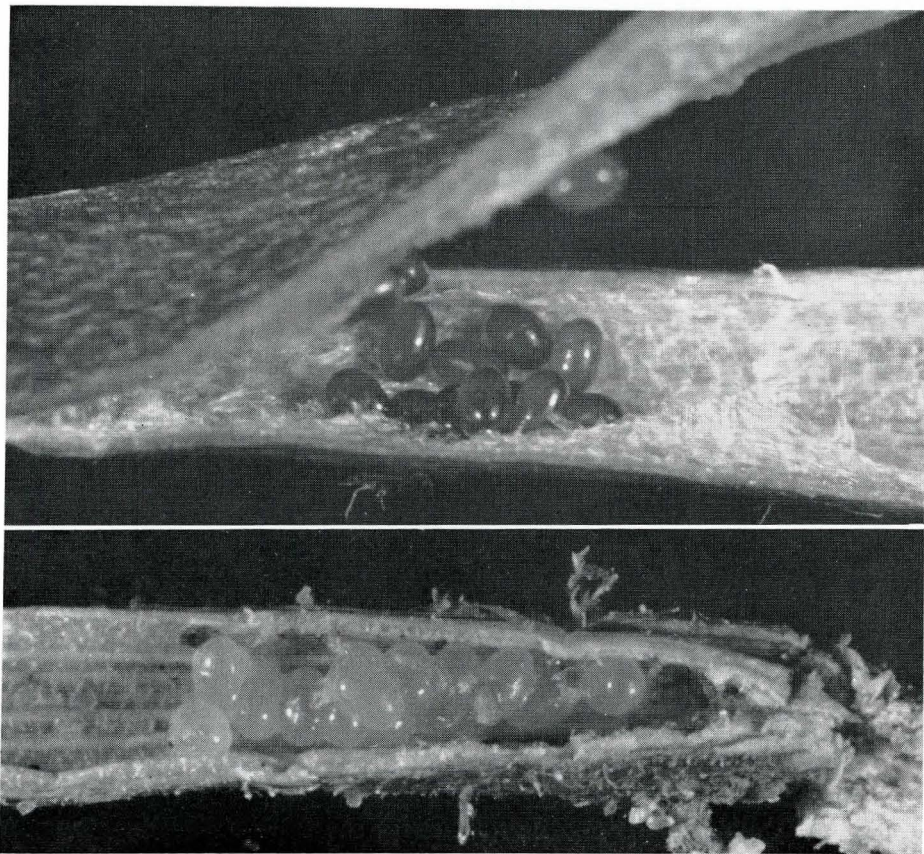


Fig. 29. A fourth-stage weevil larva feeding on alfalfa

of the first growth as a hay crop. The recommendations for controlling lygus bugs on second-crop seed are the same as for first-crop seed. However, the bloom-stage treatment can often be eliminated because troublesome reinfestation is less likely to occur.

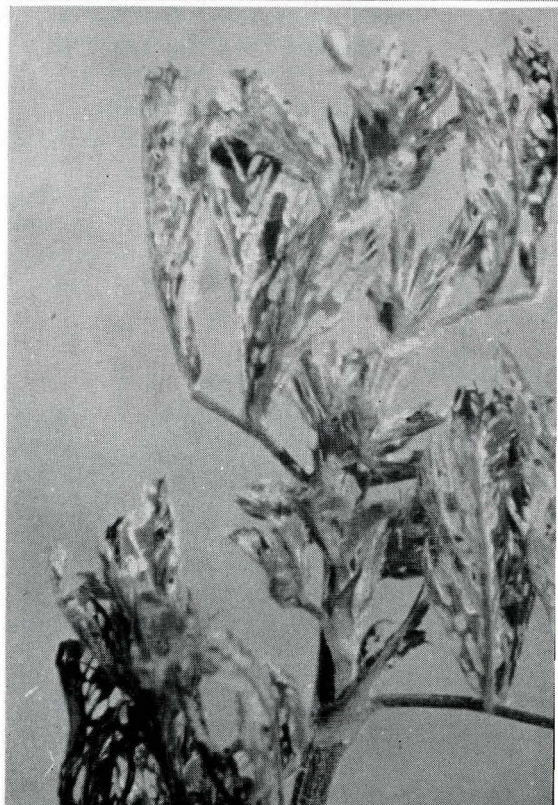
CAUTION: If you use dieldrin to control lygus do not feed the alfalfa to livestock. Do not feed alfalfa treated with toxaphene at dosages above 1½ pounds per acre or with DDT to dairy animals, animals being fattened for slaughter, or poultry. Alfalfa treated with toxaphene at lower dosages may be cut for hay or grazed after 40 days from the time of application.

Alfalfa Weevil Essentially A Pest of First-Crop Alfalfa

The adult alfalfa weevil (*Hypera postica*) (fig. 27) is a snout beetle about $\frac{3}{16}$ inch long, varying in color with age from brown to black. The beetles themselves cause little injury. Usually growers are unaware of their presence, except on warm spring days when they are sunning themselves on the tops of the alfalfa plants.

The weevil egg is tiny, oval, and lemon yellow, becoming darkened as hatching approaches. At first eggs are laid only in dead stems on the ground. After spring growth of alfalfa is about 6 inches tall, the beetles gradually shift their egg laying to growing stems (fig. 28).

Fig. 30. Leaves skeletonized by alfalfa weevil



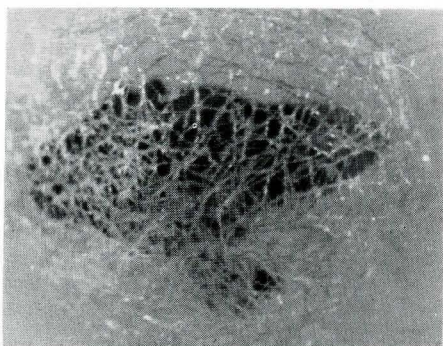


Fig. 31. Cocoon of alfalfa weevil containing pupa

The larva is the stage most familiar to growers. Newly hatched larvae are yellow with shining black heads and are $1/20$ inch long. When full grown they are $3/8$ inch long and green with a brown head and a conspicuous white stripe down the middle of the back (fig. 29). Newly hatched larvae feed within the growing plant tips. As the worms grow larger, they molt three times and feed more and more on opened leaves, which soon become skeletonized (fig. 30), dry, and take on a grayish to whitish cast which is characteristic of economic damage.

When full grown the weevil larva drops to the ground and spins a white, oval, netlike cocoon among fallen leaves or other debris. Inside this cocoon, when not parasitized, it transforms to a pupa (fig. 31), from which an adult of the new generation later emerges.

Life History and Parasitism

The alfalfa weevil spends the winter chiefly in the adult stage. Some female beetles become sexually mature before cold weather begins, and may lay a few eggs, which also overwinter. Soon after the snow covering has melted in the spring, all females become mature and begin laying eggs. Females usually lay

an average of about 400 eggs under field conditions.

Hatching of eggs in large numbers does not begin until about May 1, or later in the color valleys. Once hatching gets well started, the larvae increase rapidly, feeding ravenously on the buds and leaves, and causing economic crop damage as they become abundant in late

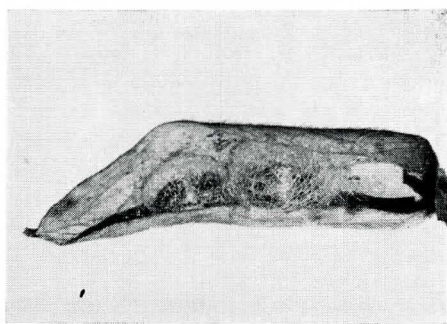


Fig. 32. Cocoons of the alfalfa weevil containing parasite cocoons

May or early June. About May 15 the first larvae become full grown and spin their cocoons. Thereafter, steadily increasing numbers complete their growth and spin-up.

Cutting of the first crop for hay will interrupt weevil development and destroy most of the eggs, larvae, and pupae before they mature. If the crop is not cut, weevil development will continue, and crop damage will increase until the insect population has run its course.

During the period that weevil larvae are feeding on the first-crop growth of alfalfa, the only important weevil parasite (*Bathyplectes curculionis*) is busy laying eggs in their bodies. Larvae so parasitized are not immediately killed but continue to feed, consuming somewhat less food but remaining able to complete their development and spin cocoons. Meanwhile, inside a parasitized weevil larva, the parasite egg soon

hatches into a larva which completes its development and kills its host after the weevil larva has spun its cocoon. The larva of the parasite emerges from the skin of its host and immediately spins a cocoon (fig. 32) of its own inside the netlike weevil cocoon. This new parasite usually remains in its cocoon until spring of the following season.

The parasite is effective in preventing weevil larvae from developing into adults, particularly during the early part of the first-crop period. The earliest weevil larvae are almost all parasitized and parasitism of larvae becoming full grown and spinning cocoons remains high (80 or 90 percent or more) until the first crop reaches the bud stage of development. After this time parasitism usually declines rapidly.

Except that parasitism of weevil larvae becomes negligible, a similar sequence of events occurs on a small scale during the second-crop period. The few old weevils still alive lay a few eggs which produce a small larval population incapable of producing damage to the

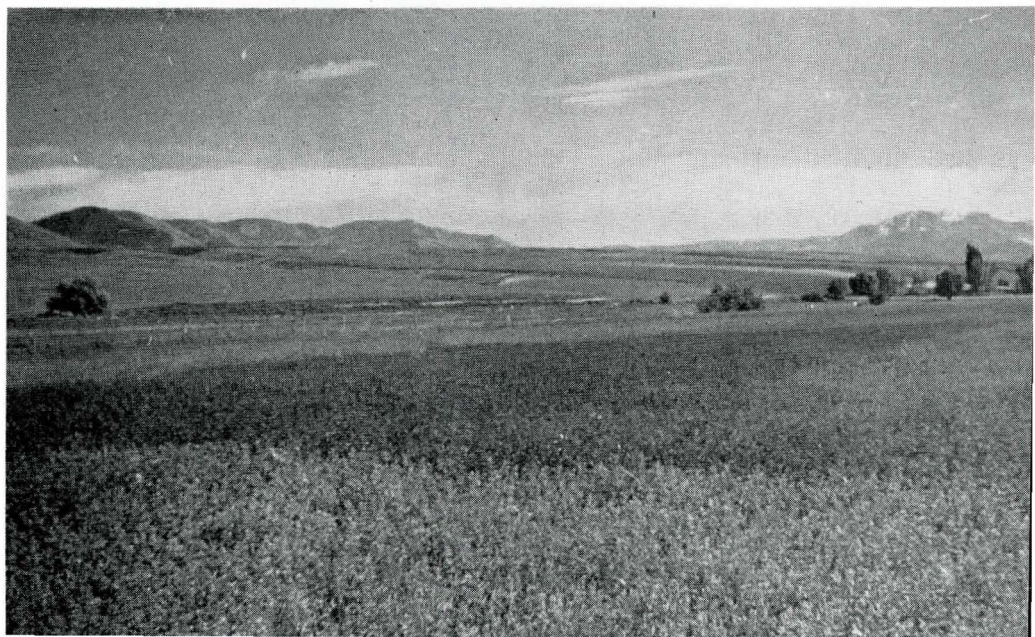
second crop or attracting attention. These few larvae begin cocooning about mid-July shortly before the second crop begins to bud. Most of them, being unparasitized, can become pupae and, later, adults.

Control

Most of the adult weevils in an alfalfa field were produced there as a result of the field's management. Migration is unimportant once the stand is established. Weevil control is therefore an individual field problem, and good control cannot be nullified by the actions of neighboring growers as is sometimes the case in lygus bug control.

The best way to prevent alfalfa weevil damage is to kill the overwintered adults early in the spring before the females have laid many eggs. Apply a recommended insecticide when the green shoots are $\frac{1}{2}$ to 2 inches long. If you are going to spray, use either heptachlor or dieldrin at the rate of 4 ounces per acre. Use at least 6 gallons of water emulsion for ground application or 2 gallons of diesel oil emulsion for

Fig. 33. Alfalfa weevil damage. The plot in the center has been sprayed to protect the crop



air application. If you prefer to dust, use heptachlor, and apply 5 ounces in 10 or more pounds of a well-prepared dust mixture per acre.

CAUTION: *If you use dieldrin for this treatment do not allow livestock to graze on the alfalfa until after the first cutting. If you use heptachlor do not allow livestock to graze on the field for 10 days.*

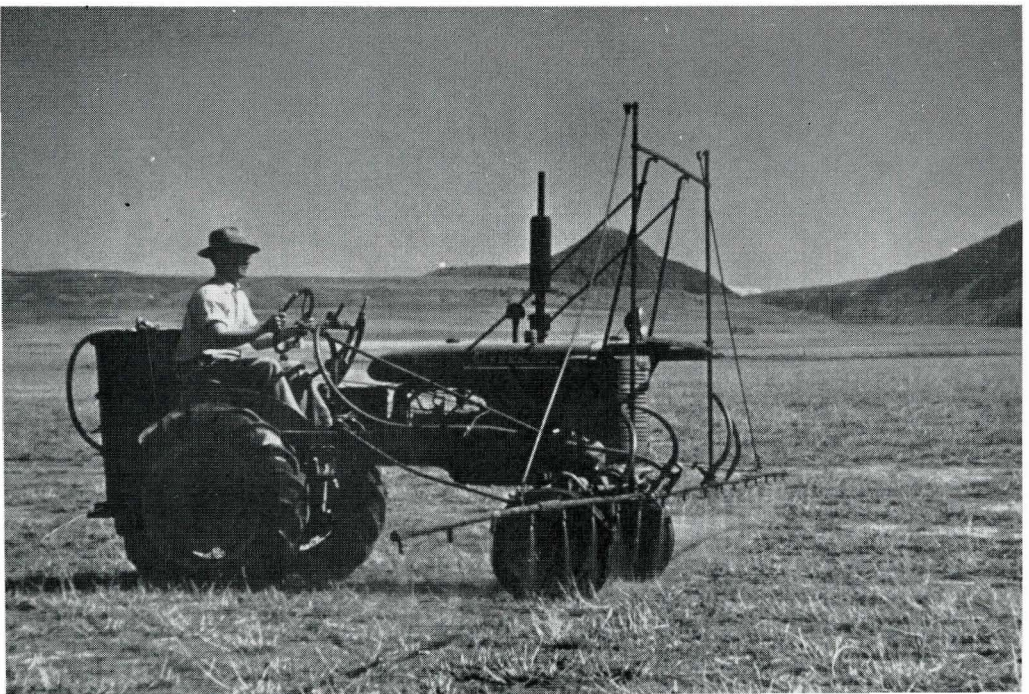
If the spring treatment is properly applied, no further treatment is necessary during the season. Some larvae will appear on the plants in May or June, but not enough to cause damage. When the first growth is used for seed production most of the larvae will be killed by the bud-stage treatment for lygus bug control.

If the spring treatment is omitted or applied too late, alfalfa weevil larvae may become numerous enough in late May or early June to cause damage (fig. 33). This damage should be prevented by an insecticide application to kill the larvae. The time to apply this

treatment coincides with or is slightly earlier than the best time to control lygus bugs (fig. 34). However, it is best to adjust the timing of the bud-stage treatment for lygus to meet the need to control weevil larvae. To control both insects in this way, best results will be obtained if dieldrin is used at a rate of 4 ounces per acre. DDT will be satisfactory at 2 pounds per acre if the weevil population is not too large. Toxaphene is not recommended for the bud-stage treatment when the spring treatment has not been properly applied. In the event second-crop seed is being grown and the spring treatment has been omitted or delayed, apply one of the treatments recommended for controlling weevil larvae on hay crops given in U. S. Dept. Agr. Leaflet 368 or Utah Extension Service Bulletin 213.

CAUTION: *If you use dieldrin for this treatment do not feed the alfalfa to livestock. Do not feed DDT-treated alfalfa to dairy animals, animals being fattened for slaughter, or poultry.*

Fig. 34. Applying the spring treatment for alfalfa weevil control



Alfalfa Seed Chalcid May Destroy Much of the Seed Crop

Description, Life History, and Injury

The alfalfa seed chalcid (*Bruchophagus* sp.) is a small, jet-black wasp about 1/12 inch long (fig. 35). The females lay eggs in developing seeds by inserting

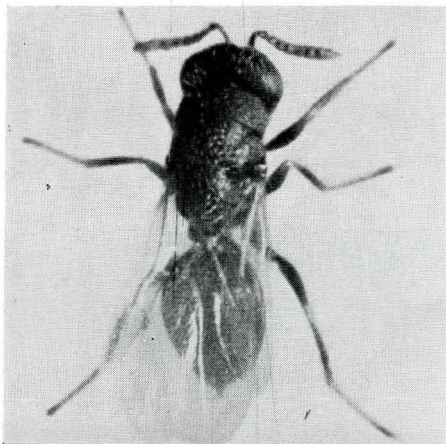


Fig. 35. Alfalfa seed chalcid

their ovipositors through both pod and seedcoat. Usually the eggs are laid in seeds that are about half grown (fig. 36). Ripe seeds are not suitable for egg laying.

Eggs hatch in about 4 days, and the young larvae hollow out the seeds and become full grown in 10 to 15 days. Only one larva develops in each seed. Pupation takes place within the seed, and the adult emerges about 12 days later by chewing a conspicuous hole through both the seedcoat (fig. 37) and ripened pod (fig. 38).

Two to three generations are produced each season. Larvae of the last generation remain within the protective seedcoats for the winter. Those that survive

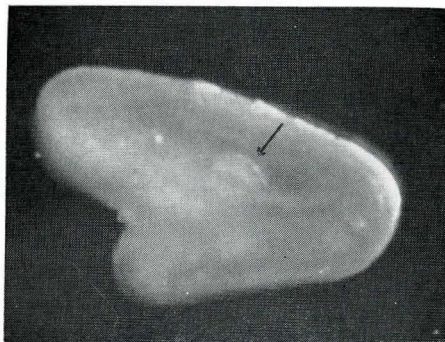


Fig. 36. An alfalfa seed containing an egg of the alfalfa seed chalcid

pupate, and emerge as adults in the spring about the time the first flowers appear on alfalfa.

Destruction of the seed is the only damage caused by the alfalfa seed chalcid, but loss from this damage can render seed production unprofitable. In Utah as much as 60 percent of a seed crop has been destroyed. Usually damage varies greatly from place to place and from field to field in accordance with sources of infestation at the time the crop begins to set. From 10 to 20 percent of the seed formed every year is lost by damage by this insect. All this loss cannot be prevented, but it can be substantially reduced by proper control measures. Control is a community problem, and every grower must cooperate if damage is to be effectively reduced.

Control

In any year the chalcid larvae living through the winter inside the seedcoats of seeds they have destroyed are the source of infestation. These infested seeds occur

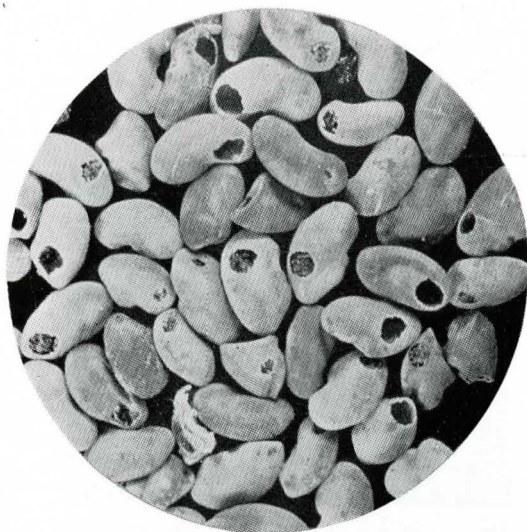


Fig. 37. Chalcid-damaged seed showing emergence hole and typical mottling of seed coat

Fig. 38. Pod from alfalfa plant showing emergence hole of alfalfa seed chalcid



- on the ground as a result of shattering of ripe pods.
- in the chaff stacks, where most of the infested seeds are blown during threshing;
- under and on plants of volunteer or other unharvested alfalfa; and
- in uncleaned seed or the screenings of cleaned seed.

Naturally, when the seed crop is harvested with a combine, the infested seeds which would otherwise occur in the chaff stack are deposited in the field. Furthermore, shattering of pods increases when the crop ripens unevenly or harvest is delayed.

The following practices are recommended for control of the alfalfa seed chalcid:

- *All farmers in a locality should grow seed from the same crop.* When first- and second-crop seed are grown in the same locality, the first crop serves as a source of infestation for the second, increasing losses.

- *The crop should be managed so as to ripen the seed as uniformly as possible.* Variations in stand and growth cause plants to vary in time of blooming, with consequent uneven ripening of seed and increased shattering of over-ripe pods during harvesting. Irregular irrigation contributes greatly to such variations.

- *Prevent all volunteer alfalfa and burclover (*Medicago hispida*) from*

forming pods. This is best accomplished by cutting or pasturing.

- *Eliminate chaff stacks before chalcids emerge in the spring.* Feed, compost, or burn the entire stack, leaving no remnants, before May 1.

- *Reclean all seed and destroy or feed all screenings.* Do not plant infested seed, and do not hold seed uncleaned. Cleaning is worth the cost.

- *Cultivation.* Harrowing with spring-tooth or disk will bury many chalcid-infested seeds. Burial actually kills the chalcid, particularly when the soil is moist. Fall cultivation is more beneficial than spring cultivation (see also section on cultivation).

The success of a chalcid control program depends on how completely all growers follow all recommended practices. The various control measures are interrelated, and neglect of one may offset the value of another. A satisfactory method of controlling the alfalfa seed chalcid with insecticides has not been developed.

Pea Aphid, When Abundant, Damages Alfalfa

Damage

In some years the pea aphid (*Macrosiphum pisi*) becomes extremely abundant in the spring, causing alfalfa 3 to 10 inches tall to become yellow and wilt down, and the damaged tops to die. During recent years midsummer populations of this pest have caused damage to seed alfalfa in some fields. Prolonged infestation results in small leaves, spindly stems, and reduced flowering. Severe infestation of blooming plants causes heavy blossom drop. Seed-

yield reductions vary from slight loss to total failure. Ordinarily a population of less than 100 aphids per stroke of a 15-inch insect net will not cause important injury.

Life History

The pea aphid is a tiny, soft-bodied, apple-green insect. Full-grown individuals are only about $\frac{3}{16}$ inch long and slightly more than a third as wide. The first aphids to appear in the spring hatch from eggs laid the previous fall on leaves and other debris lying in the

field. These aphids are wingless females, which soon become full grown. They do not need to mate to produce offspring. Their eggs hatch within their bodies, and they give birth to tiny living young, called nymphs. Twelve to fifteen generations are generally produced in a single season. Where conditions for development are most favorable, the population increase is tremendous, and plant damage usually occurs. Most of the aphids of the second and succeeding generations are wingless, but some winged aphids are usually present. All are females until the last generation in the fall. This generation consists of smaller males and egg-laying females. These females must mate before laying the eggs which carry the species through the winter.

Control

The bud stage application of DDT recommended for lygus control is usually a good early treatment for preventing midsummer pea aphid populations on seed alfalfa. If pea aphids are numer-

ous when the plants begin to bud, DDT should be applied at 2 pounds per acre, the highest dosage recommended for lygus bug control.

Other insecticides recommended for pea aphid control are parathion, malathion, and TEPP, but only TEPP, applied in the evening after 7 p.m., can be used during the bloom period without killing too many bees. Dosages per acre required for good control are 30 to 35 pounds of 1-percent parathion dust, 1 pint of parathion 25-percent emulsifiable liquid, 30 pounds of 4-percent malathion dust, 1 quart of a malathion emulsifiable liquid containing 5 pounds of malathion per gallon, or 1 pint of 40-percent TEPP emulsifiable liquid.

CAUTION: Do not feed alfalfa treated with DDT to dairy animals, animals being fattened for slaughter, or poultry. Do not feed parathion- or malathion-treated alfalfa for 15 days after application. Alfalfa treated with TEPP may be fed 3 days after the application.

Tortricid Moth Can Stop Seed Setting in an Entire Field

Injury and Life History

When abundant, the tortricid moth (*Tortrix pallorana*) can stop seed setting on an entire field. Its most important damage is the tying of racemes of flowers together in midsummer so that pollination is prevented.

This tortricid overwinters as small larvae on the dormant growth. During early spring the larvae feed almost unnoticed within single folded leaves or several leaves drawn together with webbing. When nearly full grown they

become conspicuous because of their habit of tying leaves together over the growing tips on which they feed. Pupation takes place within tied leaves and the moths (fig. 39) emerge in June. The moths lay clusters of eggs on the upper surface of alfalfa leaves (fig. 40), usually near the plant tips. Eggs hatch in about 2 weeks, and the tiny larvae quickly disperse. At first these new larvae also feed inconspicuously within single webbed leaves scattered over the plants. Later, when they move to the tops, the alfalfa is in bloom, and

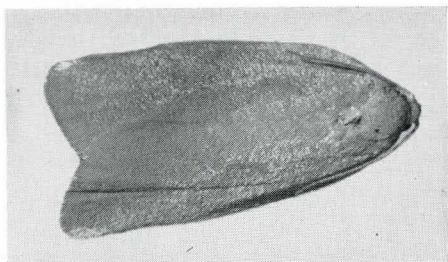


Fig. 29. Tortricid adult

they tie racemes of flowers together (fig. 41). Since bees are unable to enter these flowers, most of them are not pollinated and die. The damage is severe when the larvae move to the tops early in the flowering period.

These new-generation larvae pupate in August, and second-generation moths can usually be found in the fields from mid-August until late September. The eggs that these moths lay hatch in September, and the young larvae feed lightly on the fall growth until winter sets in.

Control

Of many insecticides tested against this pest, only parathion has been effective. Excellent control can be obtained with a water emulsion spray containing 1/2 pound of parathion per acre. Since parathion cannot be applied to alfalfa in bloom without killing bees, spraying should be done in May as soon as overwintered larvae are seen tying leaves on the tops of the plants. Killing most of these larvae in May will prevent damage by the second generation in July or August.

Usually this insect does more damage to first-crop seed than to second. Since the moths have a tendency to remain in the acreage in which they are produced

when first-crop seed is grown, good results can be expected from individual control efforts. It is advisable, however, that all noticeably infested fields be sprayed.

CAUTION: Do not feed parathion-treated alfalfa for 15 days after application.

Fig. 40. Eggs of tortricid moth

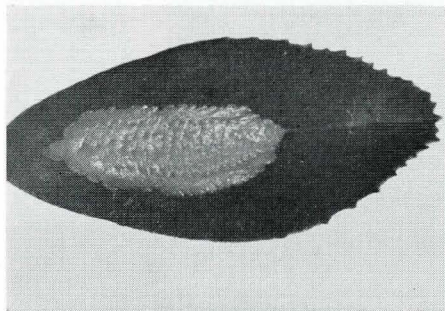


Fig. 41. A tortricid larva on a "tie" of alfalfa blossoms

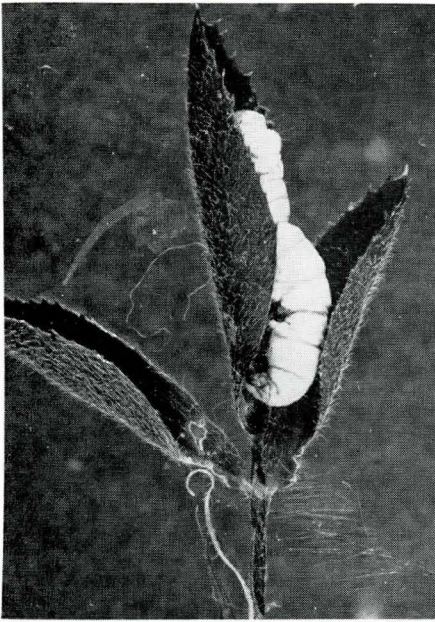


Fig. 42. Diseased tortricid larva

A virus disease of the tortricid larvae (fig. 42) is frequently helpful in controlling this pest.

Grasshoppers Cause Severe Damage When Abundant

Seed alfalfa can be damaged severely if grasshoppers (*Acrididae*) become abundant. These ravenous feeders devour leaves, buds, flowers, and young pods. Usually each grower can successfully protect his own crop economically, but when large-scale outbreaks occur community- or county-wide cooperative control programs are advisable.

Alfalfa fields can become infested either from hatching within the field or by migration of grasshoppers hatched in adjoining or nearby ditchbanks, field margins, stubblefields, weed patches, or range. Once the field becomes infested,

the best way to control grasshoppers is to spray the entire field with an insecticide. However, infestation of a field from a migration often may be prevented by timely spraying of infested areas around the field. Spray these areas as soon as you think most of the eggs have hatched.

The insecticides approved for grasshopper control are aldrin, dieldrin, chlordane, heptachlor, and toxaphene. However, because the others kill too many bees, only toxaphene should be applied to plants in bloom. When using toxaphene on blooming plants, apply it between 7 p. m. and 7 a. m.

Amounts of these insecticides recommended for spraying 1 acre are: aldrin, 1.5 to 2 ounces; chlordane, 0.5 to 1 pound; dieldrin, 0.75 to 1 ounce; heptachlor, 3 to 4 ounces; and toxaphene, 1 to 1.5 pounds. Dusts are less effective than sprays; if used, the dosages should be increased by 50 percent.

CAUTION: Alfalfa treated with the above dosages of these insecticides should not be cut for hay or grazed until after the following time has elapsed: aldrin 15 days, dieldrin 30 days, heptachlor 10 days. Alfalfa treated with toxaphene at a dosage not exceeding 1 1/2 pounds per acre may be cut for hay or grazed after 40 days. A crop treated with a higher dosage of toxaphene or with chlordane, should not be fed to dairy animals, animals being fattened for slaughter, or poultry.

Farmers can kill a large number of grasshopper eggs usually laid in field borders, along ditchbanks, and in weedy spots by cultivating these areas to a depth of 2 inches in late fall or early spring with a spring-tooth or disk harrow. In addition, infested grain stubblefields should be plowed before

May 15. Do not plow or deep-cultivate areas known to contain nests of wild bees. For more detailed instructions on grasshopper control see U. S. Dept. Agr. Farmers' Bul. 2064.

Yellow-Striped Armyworms Sometimes Devour the Flowers

Outbreaks of yellow-striped armyworms (*Prodenia praefica* and *P. ornithogalli*) (fig. 43) occasionally cause considerable damage to seed alfalfa by devouring the flowers. Damaging populations may develop after the plants bud either from eggs hatching within the field or from worms migrating from other infested crops. Toxaphene is the most effective insecticide against yellow-striped armyworms, and DDT will also control them. Growers following the control program recommended for lygus bugs ordinarily will not be troubled. When specific control is required apply toxaphene at the rates and under the conditions recommended for control of lygus bugs. Heavier applications around borders of fields will reduce entry of migrating worms. Frequently, a virus disease of these worms (fig. 44) helps to control them.

Thrips and Leafhoppers Controlled by Lygus Treatments

Thrips and leafhoppers commonly become abundant in seed alfalfa fields. In the Intermountain Area their damage is minor and they are effectively controlled by the insecticide applications recommended for lygus bug control.

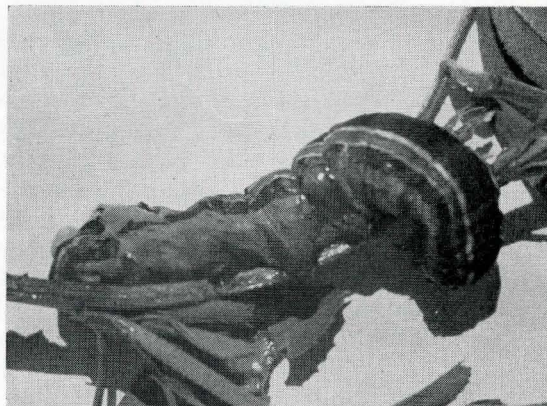
Spider Mites More Serious Since Advent of DDT

Spider mites (*Tetranychidae*) are so tiny they usually go unobserved until



Fig. 43. Western yellow-striped armyworm

Fig. 44. Diseased yellow-striped armyworm



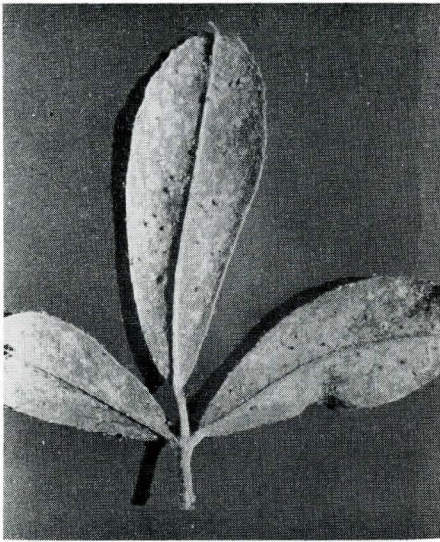


Fig. 45. Alfalfa leaves showing mites and their damage

they have become abundant and have caused considerable damage to plants. In several recent seasons some alfalfa has been economically damaged by them, and interest in their control has been aroused among seed growers. Unfortunately, since the introduction of DDT as an insecticide, outbreaks of mites have been repeatedly associated with its use. DDT does not control mites, but readily kills predatory insects that otherwise would keep them to non-injurious numbers most of the time.

The mites generally occurring on alfalfa are called red spiders. They may be yellow, green, or red, and often have indefinite dark spots on the body. Their eggs are clear or flesh colored and spherical. These mites usually confine their activities to the underside of the leaves, where they feed, lay eggs, and spin delicate webs. They occur first on the bottom leaves of a plant, and gradually move upward to the tips. The mites pierce the cells of the leaves through the lower surface and suck out the juices.

The damaged leaves acquire a mottled appearance (fig. 45) as the cells die and gradually turn completely brown and drop. When conditions are favorable for the mites, they become abundant, destroy almost all the leaves on the plants, swarm to the tops, and spin great amounts of webbing over the tips of the stems. Others migrate through the air on strands of webbing or by crawling on the ground and seek out fresh plants on which to feed and multiply. They overwinter as adults on debris in and around the field.

Mites should be controlled before they become abundant. Cultivation in the fall or spring and between crops will reduce the likelihood of a menacing mite population. Mites usually cannot free themselves from soil when buried at least 1 inch deep. Loose soil helps make migration difficult. Dusting sulfur kills mites and appears to be the material most practical to apply to plants for early preventive control. In fields where mites are considered a threat to seed production, sulfur should be applied before the plants bloom. In hot weather sulfur sometimes burns flowers and causes them to drop. Ordinarily two applications of dusting sulfur at the rate of 10 to 25 pounds per acre, 10 days apart, are recommended. However, a single application may often be adequate to keep mites from causing economic loss. If the DDT applied in the bud stage is in the form of a dust, sulfur may be added. Ten percent DDT dusts containing 50 percent of sulfur would provide the minimum dosage of sulfur (10 pounds per acre); 10 percent DDT dusts containing as high as 75 percent of sulfur can be obtained from insecticide companies.

CAUTION: Do not feed alfalfa treated with DDT to dairy animals, animals being fattened for slaughter, or poultry.

Insecticides Kill Bees

Most of the insecticides recommended today are toxic to both honey bees and wild bees. Their use on alfalfa in bloom will frequently cause a high mortality of bees visiting the alfalfa flowers. Because the pollinating activity of these bees is

essential to seed production, growers must avoid killing too many bees while controlling injurious insects. Control measures recommended in this circular, are designed to minimize losses of bees as well as kill pests.

Residues of Insecticides in Alfalfa Chaff Require Caution in Feeding

Alfalfa chaff has long been utilized as livestock feed. Sold as such, it has consistently brought from one third to one half the current price of alfalfa hay. The widespread use of DDT and other organic insecticides on seed crops, with consequent better crop returns, has not

appreciably altered this practice. Therefore, precautions on the feeding of insecticide-contaminated chaff are necessary. Growers should carefully follow the instructions given on the container label in regard to the feeding of insecticide-treated alfalfa to livestock.

Insecticides are Poison — Handle With Care

- Most insecticides are poisons and must be handled with care. Follow the directions and heed all precautions on the container label.
- In handling or mixing concentrated insecticides avoid spilling them on your skin and keep them out of your eyes, nose, and mouth. If accidentally spilled on the skin or clothing, wash off and change clothing immediately. Wear a respirator if you are working in high concentrations of sprays or dusts during loading or mixing operations.
- In applying dusts or diluted sprays avoid repeated exposure. After using insecticides, bathe thoroughly and change to clean clothing.
- Parathion and TEPP are partic-

ularly dangerous and may be absorbed through the skin, eyes, lungs, or mouth. Persons handling these insecticides should wear a gas mask or respirator equipped with a canister of a type recommended by the U. S. Department of Agriculture. Parathion and TEPP should be applied with power machines only and by persons experienced in handling poisonous chemicals.

- If you accidentally swallow an insecticide, induce vomiting by taking 1 tablespoonful of salt in a glass of warm water. Repeat if necessary. Call a doctor.
- Store insecticides in a dry place where children and animals cannot reach them. Be sure that they are clearly labeled.

Section III. Pollination

GEORGE E. BOHART, WILLIAM P. NYE, AND MARSHALL D. LEVIN

ALFAFA MUST be cross-pollinated (fig. 46) by bees to set high yields of first quality seed. Attempts to develop satisfactory self-fertile varieties or to substitute chemical applications or mechanical trippers for bees have been unsuccessful. To insure rapid and thorough pollination the field must be supplied with enough bees to do the job.

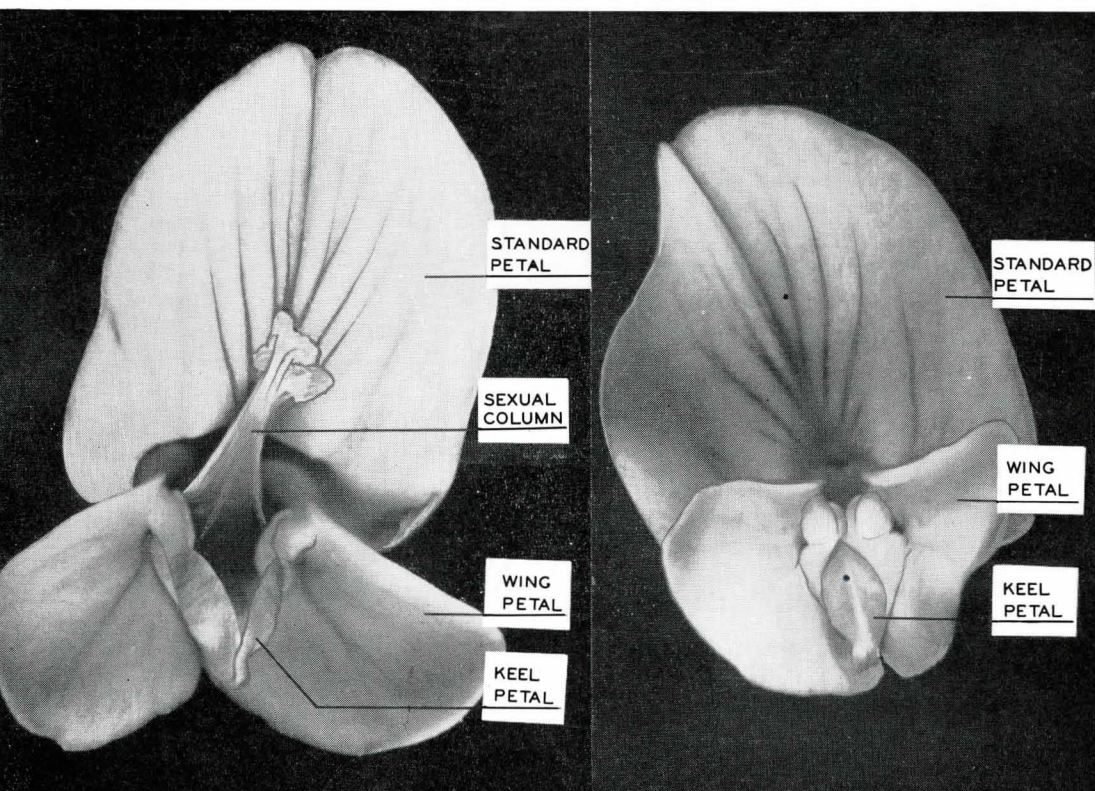
When alfalfa pollination is rapid the field never develops the appearance of full bloom. Flowers that wilt and begin to set pods before the racemes are fully open give the field a dull, brownish cast (fig. 47). If your field develops the flower-garden look, you should take the following steps to improve pollination:

- keep your alfalfa in a condition attractive to bees;
- eliminate competing sources of pollen and nectar;
- have a sufficient supply of bees in the area.

Attractiveness can be controlled best by the individual grower and should be taken care of first. Since the details for carrying out these steps differ somewhat for the different kinds of pollinators, they will be discussed separately.

More than 60 species of bees pollinate alfalfa in the Intermountain States, but only about 20 of them are commonly encountered. In a single field it is un-

Fig. 46. Alfalfa flowers, left, tripped; right, untripped



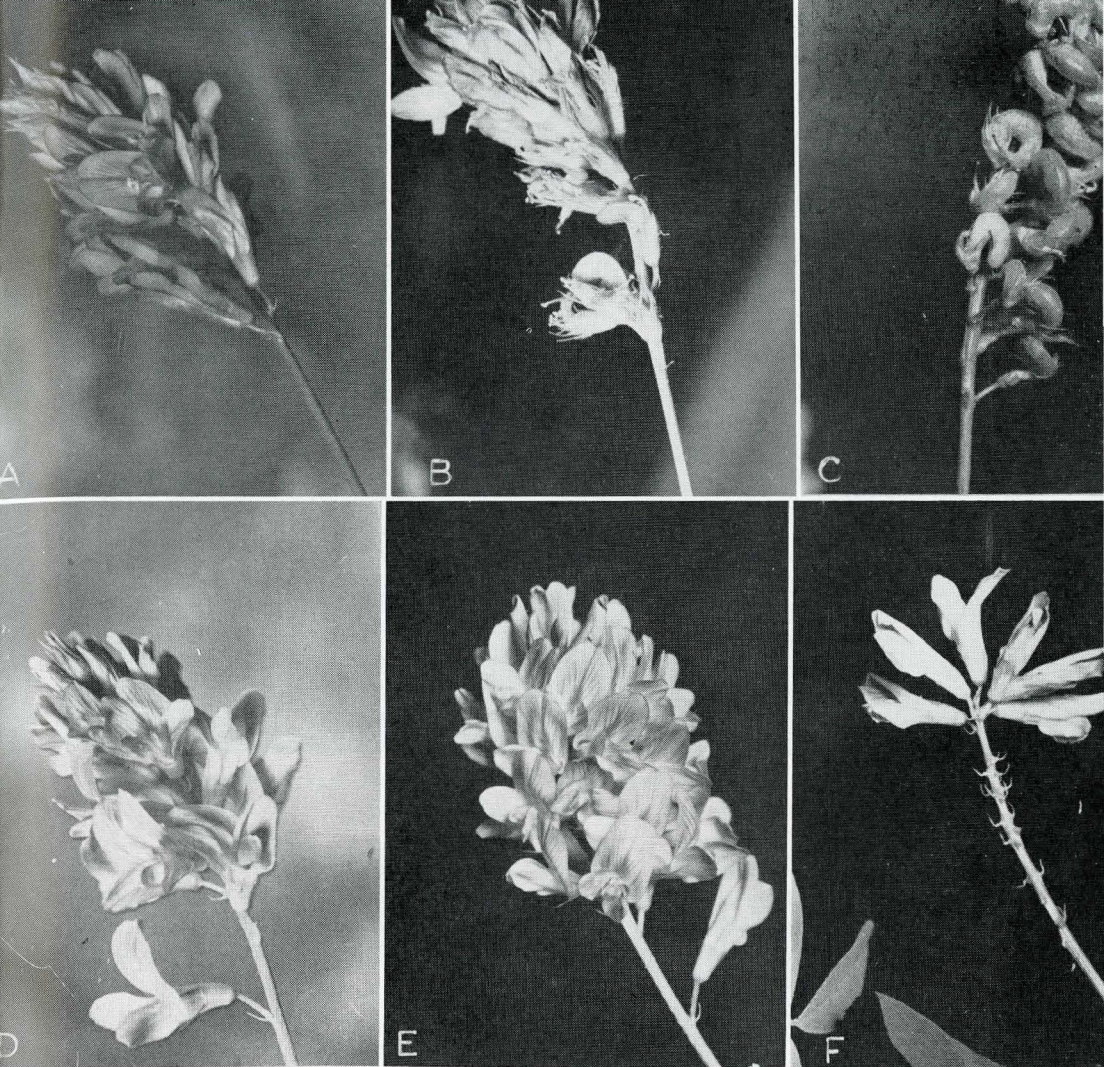


Fig. 47. A to C, progress of a raceme pollinated by bees and D to F, raceme protected from bees

usual to find more than five abundant enough to be of practical importance. The more important pollinators of alfalfa in the Intermountain Region are:

honey bees (1 species), alkali bees (1 species), bumble bees (6 species), leaf-cutting bees (5 species), and others (8 species).

Honey Bees Most Important and Abundant Pollinators of Alfalfa

Honey bees are the most abundant and important alfalfa pollinators in most

western seed areas. On alfalfa they divide themselves into two working



Fig. 48. Honey bee collecting alfalfa nectar (note side approach to floret)

forces, nectar collectors (fig. 48) and pollen collectors (fig. 49). Their relative efficiencies are indicated below.

	Nectar collectors	Pollen collectors
Percent of flower visits causing tripping	1+ —	80+ —
Flowers visited per minute	14	8
Flowers pollinated per hour	8.4	384
Relative efficiency rating	1	45

Nectar Collectors If Numerous Can Set A Fair Crop

In spite of their slow rate of tripping, nectar collectors in sufficient abundance can set a fair crop of seed. A field with a good agronomic potential for seed production and an average of six nectar collectors per square yard, tripping at

the rate indicated above over a 3-week period will produce 350 plus pounds of seed per acre. Few seed fields in Utah have such dense populations. However, even larger populations are possible if the plants are maintained in an attractive condition and there are as many as five colonies of bees per acre of all bloom within a radius of 2 miles.

An unattractive field may not be visited by more than one or two bees per square yard no matter how many colonies are brought into the area. An attractive field in a heavily stocked area may attract as many as eight or more bees per square yard. If your field does not attract at least five honey bees per square yard when the area is well stocked, you should increase the attractiveness of the field. Even if it is impossible to supply the area with a

heavy concentration of bees, making the field attractive will pay off in greater visitation by available pollinators.

Pollen Collectors Much More Efficient

Because pollen collectors are much more efficient in tripping than nectar collectors, a few of them added to the nectar bee population on a field makes a big difference in the rate of pollination. Theoretically one pollen collector for every 10 square yards should trip about as many flowers as the five nectar collectors per single square yard mentioned previously as being capable of setting a 350-pound seed crop. However, bees on a pollen-collecting trip usually spend a number of minutes taking nectar alone. Consequently some of the bees in the field with pollen loads are temporarily equivalent to nectar collectors. Furthermore, populations of pollen collectors fluctuate much more than nectar collectors from hour to hour and from day to day, so more leeway must be allowed in evaluating their work. In general, if each pollen collector is considered equivalent to 20 nectar collectors, a fair judgment can be made of the efficiency of the whole honey bee population. On this basis, five bees per square yard, 5 percent of them pollen collectors, could be expected to set a 700-pound seed crop under good conditions.

The only known methods for increasing the percentage of pollen collectors on the field are to maintain it in a condition attractive to pollen collectors and to eliminate competing sources of pollen.

Steps to Improve Pollination by Honey Bees

Making the Field Attractive. The first consideration should be the attractiveness of the field. An open, upright,

strongly flowering type of growth is attractive to both nectar and pollen collectors. Pollen collectors appear to avoid a rank type of growth even more than do nectar collectors. However, since large plants are necessary for high seed production, moisture should not be low enough to cause stunting (see agronomic sections on stands and moisture).

Eliminate Competing Sources of Pollen and Nectar. Control of competing pollen and nectar sources should be the next consideration. Since colonies per acre must be considered on the basis of total acres of bloom within a radius of at least 1½ miles from the colonies, it is wise to limit the acreage of bloom that is not going to produce alfalfa seed. Alfalfa hay should not be allowed to flower extensively; corn, safflower, sorghum grains, and other crops that produce attractive bloom when alfalfa is blooming should not be produced within a mile or more of alfalfa seed; pas-

Fig. 49. Honey bee collecting alfalfa pollen (note direct approach to floret)



tures containing sweetclovers (*Melilotus* spp.), true clovers (*Trifolium* spp.), and grasses that bloom in competition with alfalfa should be closely cut or pastured during the pollination period of the alfalfa. Better yet, they should not be produced in the same area as the alfalfa seed. Weeds and plants that produce attractive bloom simultaneously with alfalfa should be eliminated within at least 1½ miles from the colonies. Sweetclovers, true clovers, mustards (*Lepidium*, *Descurainia*, *Sisymbrium*, and *Brassica* spp.), and gumweed (*Grindelia squarrosa*), are the top weed competitors in many localities in the Intermountain Region. Saltgrass (*Distichlis stricta*), Russian-thistle (*Salsola kali*), greasewood (*Sarcobatus vermiculatus*), povertyweed (*Iva axillaris*), and ragweed (*Ambrosia* spp.) are often abundant but appear to be somewhat less attractive. Other weeds may often be locally abundant and highly attractive.

Because pollen collectors are much better pollinators than nectar collectors, elimination of competition is especially important in the case of plants attractive for pollen. Unfortunately, pollen collectors are more readily attracted than nectar collectors to other kinds of plants. Consequently, more thorough control of competing plants is necessary to increase pollen collectors on alfalfa. Experience has shown that half measures do little to increase collection of alfalfa pollen. Unless control can be nearly complete for at least a mile radius and include crops, range plants, and weeds, little benefit may result insofar as increase of pollen collectors is concerned.

Control of competition is easiest on new land where weeds are not yet a serious problem and where farming is not diversified. The use of underground drains and irrigation lines and

the elimination of permanent fences greatly facilitate weed control. Control of pollen and nectar sources, like several other factors in alfalfa seed production, can be handled best by community effort.

Provide the Bees. The third consideration is obtaining and placing colonies of bees (fig. 50). Seed growers need answers to the following questions:

● **How Many?** The number of bees in the field and the percentage of pollen collectors (either honey bees or wild bees) are the best indications of the number of colonies needed. If competing plants are scarce and the field is attractive, 3 to 4 colonies per acre should result in field populations of 6 or 8 bees per square yard. If as many as 10 percent of these are pollen collectors, pollination will not be a limiting factor. With higher percentage of pollen collectors, fewer bees will be necessary. When less than 1 percent of the bees are pollen collectors, 5 or 6 colonies per acre can be used to advantage. However, if the field is surrounded by acres of attractive bloom, all such acreage within 1½ miles should be considered in deciding upon the number of colonies to be brought into the area. In most cases elimination of competing sources is more practical than trying to saturate them and will have better results. If the competing bloom is in alfalfa seed fields belonging to other growers, nothing short of a cooperative endeavor to provide bees for all the seed fields is likely to succeed.

● **How Strong?** Strong colonies with plenty of brood are recommended. In a heavily stocked range the stronger the colonies the better they maintain themselves. Also, the larger the amount of brood the more stimulus there is for pollen gathering. Furthermore, strong

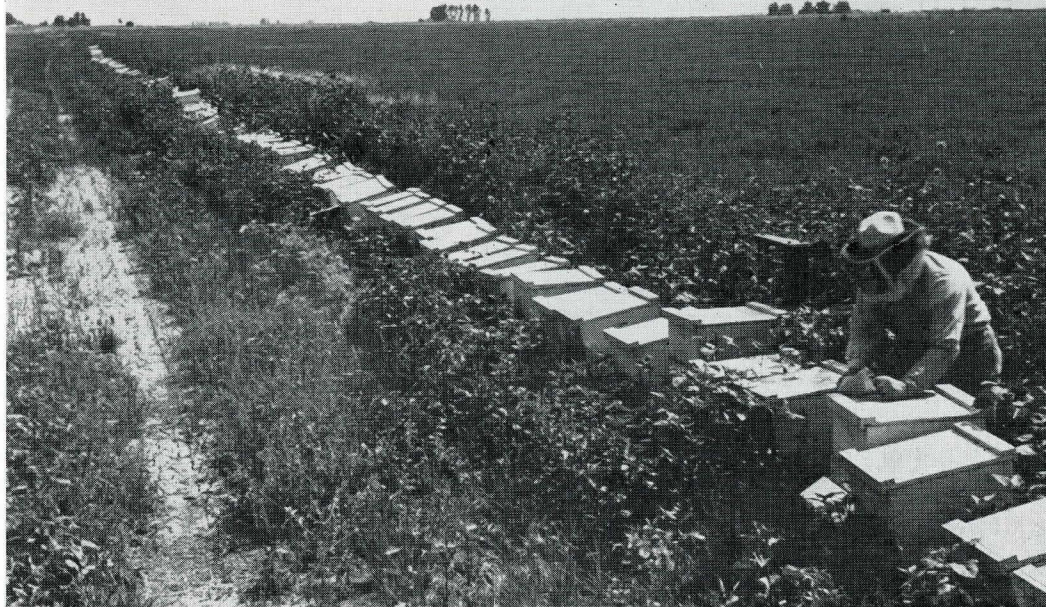


Fig. 50. Honey bee colonies for alfalfa pollination

colonies insure a continuing supply of inexperienced bees which, it has been shown, trip more flowers as nectar collectors than do bees with a day or more of experience.

● **Where Placed?** For fields with fewer than 10 acres the colonies can be placed adjacent to the field. It is best to place them within larger fields. If the field is 1/2 mile or more across, the colonies should be distributed in groups no more than 1/4 mile apart. In the first place, bees from colonies in the center of a large acreage of alfalfa must fly considerable distances to reach competing plants. In the second place, although honey bees can distribute themselves uniformly over great distances from the colonies, they are thereby wasting valuable working time and energy in just flying to and from the flowers.

● **When Placed?** At least some of the colonies should be brought to the field as soon as it starts to bloom. To

avoid the possibility that many bees will become oriented to other sources first, the rest of the colonies should not be placed in the field until early bloom is well established.

● **When Removed?** Under intermountain conditions flowers tripped after August 20 are not likely to develop mature seeds by harvest. Consequently, from the standpoint of pollination, hives may as well be moved out at that time.

● **How Obtained?** Honey bees are best obtained from beekeepers. Few seed growers will have the time or skill to keep the number of colonies needed for alfalfa pollination.

● **Community Effort Important.** With a little encouragement beekeepers will place as many colonies in an alfalfa seed area as they think will make them a good honey crop. This is usually not over one colony per acre, although some beekeepers are willing to place as many

as two per acre if the bloom is heavy. Beekeepers may be encouraged to place their bees in or next to a seed field regularly if (1) suitable locations are provided and (2) assurances are given that bees will not be killed by improper use of insecticides (see section on control recommendations). In many cases cooperation of neighboring growers must be obtained to prevent bee poisoning.

To obtain the use of more than one to two colonies of bees per acre of bloom, the seed grower will generally have to pay the beekeeper. Payment for pollination has rarely been practiced in seed areas of the Intermountain Region. Several attempts have been made, but most of the agreements have turned out to be unsatisfactory to one or both parties. Failures have usually been attributed to one or more of the following conditions:

- inadequate insect control, or poor or unattractive bloom resulting from alfalfa being too dense (frequently a hay-type stand),
- too much acreage of neighboring

growers not contributing to the arrangement,

- low seed potential on dry land fields with inadequate moisture,
- excessive amounts of sweetclover, gumweed, and other competing weeds in the area.

Success with pollination by honey bees does not always come easily, but growers who take pollination for granted should consider the high seed yields produced where intensive cultural practices are augmented by equal efforts to provide bees for pollination. In California contracts between seed growers and beekeepers are usually entered into by all growers in an area and are handled through associations to assure equitable cost and distribution of bees.

It is obvious that a strong supply of honey bees well distributed over the seed-producing area can best be provided by community action. Potentially, seed growers and beekeepers are partners in an enterprise, but because of the wide-ranging habits of bees this partnership can only be satisfactory on a community-wide basis.

Wild Bees are Efficient Pollinators

The term "wild bees" refers to the various species native to this country and does not include honey bees, whether they come from apiaries or wild colonies. Wild honey bees perform on alfalfa in the same manner as domestic ones, but their activity should be discouraged since their hives serve as reservoirs of apiary diseases.

That wild bees are efficient pollinators of alfalfa has been recognized for many years by scientific investigators and seed

growers alike. In fact, until recently they have been considered as the only important pollinators.

With few exceptions wild bees visit alfalfa for pollen as well as for nectar. Many species seem to have a special knack for tripping the blossoms to get at the pollen (fig. 51) whereas others have much difficulty and a number of small species content themselves with blossoms that have already been tripped. In general, bees more than 3/8 inch

Fig. 51. A wild bee (*Megachile texana*) tripping alfalfa flowers



Number of Bees Needed

By relating tripping rates and working hours of bees to the number of flowers in a stand and the percentage of tripped flowers forming pods, it is possible to make a rough estimate of the numbers of various kinds of bees required to set a particular seed crop. On this basis it has been estimated that about

Table 1 Number of alfalfa flowers tripped per minute by various kinds of bees (California, Utah, Kansas, Saskatchewan)*

Genus of bees	Number of species observed	Flowers tripped per minute	
		Average for all species	Range between species
MEGACHILE (leaf-cutting bees)	7	17	15-20
BOMBUS (bumble bees)	7	17	13-21
NOMIA (alkali bees)	2	13	10-17
XYLOCOPA (carpenter bees)	1	23
OSMIA (osmia bees)	1	18
MELISSODES (long-horned bees)	4	9	8-10
APIS (honey bees)			
(pollen collectors)	1	7
(nectar collectors)	1	0.1 (approx.)

*Observations by Linsley, MacSwain (California); Peck, Bolton (Saskatchewan); Franklin (Kansas); Bohart (Utah).

one pollen-collecting bee per 10 square yards over a 3-week period would be required to set a seed crop of 400 pounds per acre. The more efficient bees, such as bumble bees and leaf-cutting bees need not be quite so abundant, and the less efficient ones, such as alkali bees and pollen-collecting honey bees should be somewhat more abundant.

Number of Bees Available

Unfortunately, wild bees are not present in most seed fields in sufficient numbers to set a satisfactory crop. Their distribution is uneven, but even if they could be spread more evenly over the acreage to be pollinated their numbers would not be adequate for the task. It must be admitted that we have only begun to learn how to increase wild bees and move them to places where they are needed, as we can so readily do with honey bees. Not only are wild pollinators scarce in most alfalfa fields, but many species seem to be in a state of progressive decline, if one may judge

from past trends. It has been common experience for areas newly opened up to crop production to have excellent seed yields and then for yields to decline within a few years. Increase of injurious insects may be responsible in part, but farmers and investigators have both observed that wild bee populations often decline drastically within a few years after an area has gone under cultivation. It is probable that this decline results from several causes, including destruction of nesting sites, increase of acreage to be pollinated, and killing of bees by insecticides. Destruction of food plants that bloom earlier than alfalfa probably also plays an important part.

Life History, Protection, and Utilization

A basic knowledge concerning the value, distribution, life history, and living requirements of the more important types of wild bees must precede any attempt to outline definite measures the seed grower might take to improve pollination on his fields by wild bees. The

Fig. 52. Alkali bee starting her nest excavation





Fig. 43. Portion of an alkali bee nesting site showing wind-blown entrance mounds among clumps of saltgrass and samphire

three most commonly encountered wild pollinators in the Intermountain Area are alkali bees, bumble bees, and leaf-cutting bees.

Alkali Bees the Most Important Wild Pollinators

The alkali bee (*Nomia melanderi*) is the most important wild pollinator in the Intermountain Area and the state of Washington. Many of the consistently high seed yields reported from southeastern Millard County and the Uinta Basin in Utah are taken from fields near large nesting sites of alkali bees. This is the only species that shows much promise for management by seed growers. In Washington seed growers have already successfully developed new nesting sites by following recommendations of the Utah and Washington Experiment Stations.

Alkali bees are about two-thirds as large as honey bees and can be readily

recognized by the pale green or greenish-bronze, highly polished bands across the rear portion of their bodies (fig. 52). They are found principally in the larger valleys where poorly drained, alkaline areas are prevalent. They are abundant in some areas and totally absent in others. It is also common experience for them to appear in numbers in one season and to disappear almost as quickly several years later.

The host range of alkali bees is rather limited. In the Delta area of Utah only sweetclover and Russian-thistle offer serious competition to alfalfa, although a few other less abundant plants such as saltcedar (*Tamarix gallica*), morning-glory (*Convolvulus* sp.) and various clovers are attractive. Common competitors in the area for honey bees such as greasewood, povertyweed, gumweed, sunflower (*Helianthus annuus*) and rabbitbrush (*Chrysothamnus* sp.), present no attraction for alkali bees.

Alkali bees construct their nests close together to form nesting aggregations (sometimes loosely spoken of as colonies or communities). However, each female is solitary. She functions as both queen and worker and constructs and provisions an individual nest burrow in the fall. An aggregation may cover an acre or more with burrows many of which are not more than an inch or two apart. The population of such a nesting site compares favorably with that of honey bees in an average apiary (50 colonies).

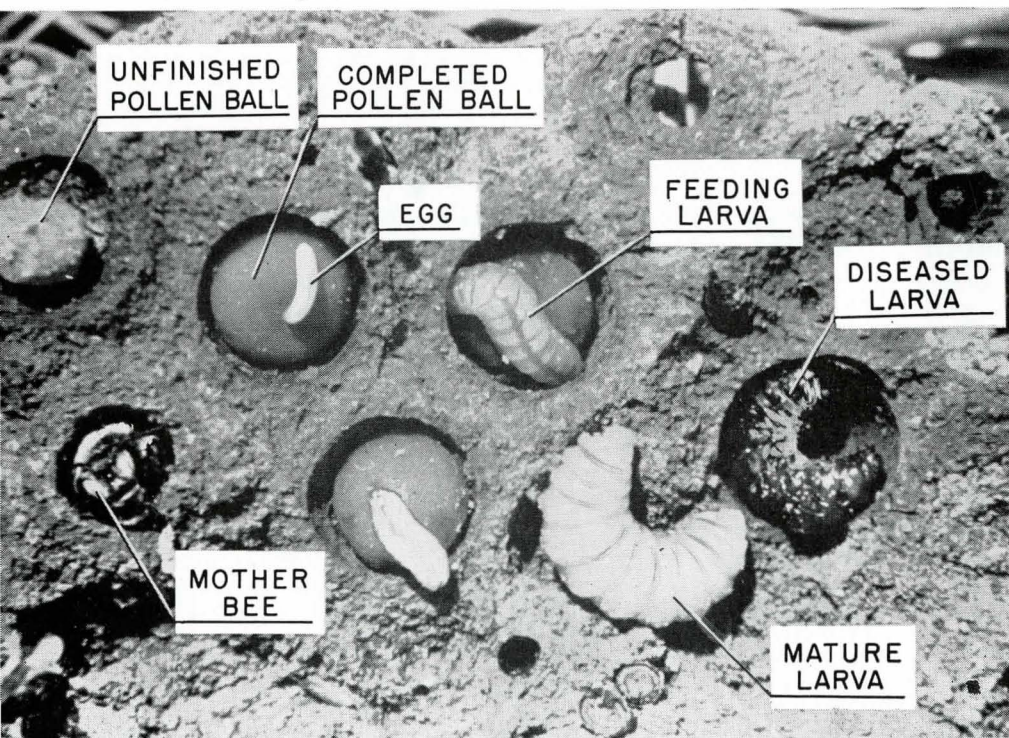
Nesting takes place in fine-textured, somewhat cohesive soils of either a sandy or clayey nature. The prime essential seems to be a high year-round moisture content, although the area should not be flooded in the summer or for extensive periods in the winter. Nesting sites may be on bare ground but are usually associated with a sparse, short growth of saltgrass, smotherweed (*Bassia hyssopifolia*), pickleweed (*Allenrolfea occidentalis*), or samphire (*Sal-*

icornia spp.) that allows direct light to reach the ground (fig. 53). The alkali deposited in the soil by underground water prevents excessive growth of vegetation.

An individual nest consists of an entrance mound at the ground surface and a vertical underground burrow branching into two groups of brood cells, one about 4 and the other about 7 inches deep. Each level is comprised of 5 to 10 oval cells placed side by side rather close together (fig. 54). After constructing a small group of cells, the bee provides each cell with a ball of pollen, places an egg on the ball, and seals the cell. The young larva, after hatching from the egg, must complete its development without further assistance.

In Utah, Idaho, and Wyoming adult male alkali bees usually appear in the fields near the first of July. Females often do not appear in numbers until the middle or even the end of July. Males in the field are restless and stop only

Fig. 54. Horizontal section of an alkali bee nest at the cell level



occasionally to feed on nectar from flowers. However, they do trip a high percentage of the flowers visited, and we have observed fields in which they have been the most important pollinators. Females work much more efficiently than males. The grower, in order to take full advantage of alkali bees, must time his bloom for late July or early August. Since there is a partial second generation, some adults may be found until September. By early September, when most of the host flowers have gone to seed, the adults perish, but their offspring remain in the soil as mature larvae until the following summer. Basic features in the seasonal life history of an aggregation of alkali bees are summarized in table 2.

Since alkali bees are gregarious and are also rather exacting in their nesting requirements, it is important that their nesting sites be protected from disturbance. During the active season any disturbance such as harrowing, flooding, and trampling can be disastrous. During the fall, winter, and spring months pasturing, light watering, and shallow harrowing should not be harmful unless the surface is left in a loose condition that insulates the soil and delays emergence of the bees. Nesting areas should not be drained or leached. Application of insecticides during bloom is hazardous to alkali bees and should be

done only according to recommendations (see section on control recommendations).

The greatest number of nesting sites are found in seeped areas resulting from the underground movement of irrigation water. The establishment of new irrigation districts, or the expansion of old ones, is often followed by a rapid increase in the number and size of the nesting sites. Whole aggregations often migrate into a new site in a single season. Consequently, the seed grower in a favorable area may prepare and maintain favorable sites near his alfalfa and wait with reasonable optimism for natural occupancy. Growers should be mindful, however, of the need for retaining the seeped areas and be aware of the danger of "killing the goose that lays the golden egg" by overzealous programs of drainage and water conservation.

Bumble Bees are Important Where Their Numbers are Sufficient

Bumble bees (*Bombus* spp.) (fig. 55) are the large furry bees familiar to everyone. In the West they tend to be most abundant in small valleys and along foothill benches. A few species may be found in small numbers in larger valleys. However, in only a few small fields have they been seen in the numbers necessary

Table 2 Typical course of events in nesting sites of alkali bees in Idaho, Utah, and Wyoming

Mid-September-June	Full grown larvae in cells in ground.
Early July	Males emerge, visit some flowers.
Mid-July - early August	Females emerge, visit flowers and produce larvae.
Early - late August	Most larvae prepare for hibernation but a few develop into second generation adults.
Late August - early September	Second generation adults complete nesting activities, perish.
Mid-September - June	Progeny of first- and second-generation bees carry through winter as larvae.

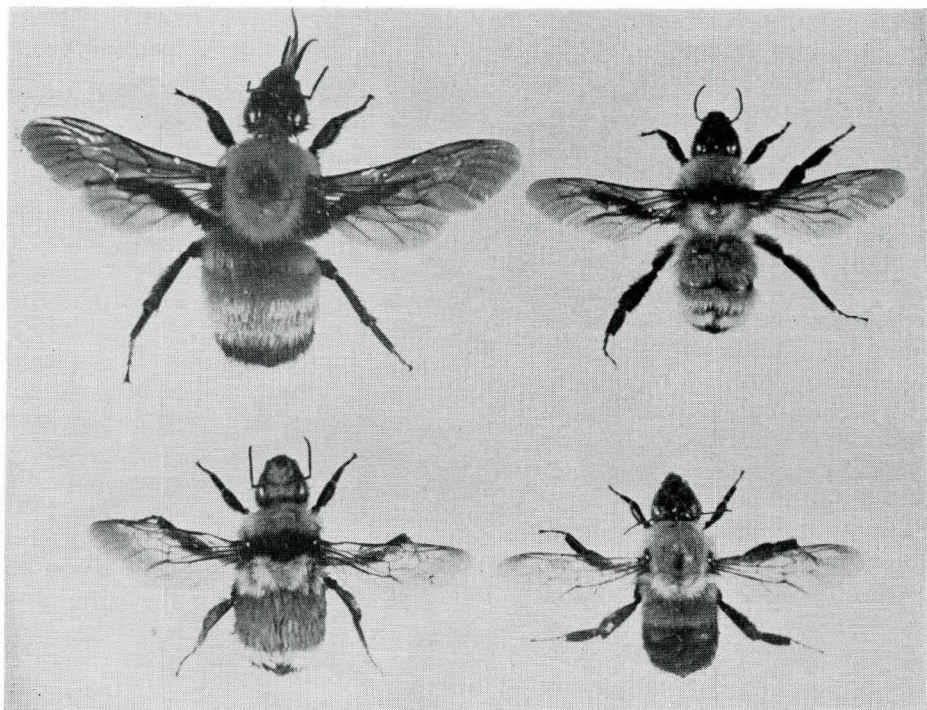


Fig. 55. Four species of bumble bees that pollinate alfalfa in the Intermountain Region: *Bombus nevadensis*, *Bombus fervians*, *Bombus huntii*, *Bombus mormonorum*

to set a good seed crop. In Utah and southern Idaho six kinds have been seen in various fields in important numbers. Most of these have a wide host range, but they usually limit their visits to rather showy flowers. Many legumes and composites are attractive to them and offer competition to alfalfa for their visitation. Adequate bloom of some host plant early in the season when the colonies are getting started is necessary if they are to build up useful numbers.

Bumble bees are like honey bees in that they form colonies and possess queen and worker castes. The principal difference is that bumble bee colonies die out in the fall except for young, fertilized queens that scatter out and carry the species through the winter. In the

spring each of these queens must establish a new colony (fig. 56) (commonly in abandoned rodent nests) and provide for a brood of workers before she can retire to a life of egg laying. Another striking difference is the small size of bumble bee colonies (fig. 57). Generally they attain a maximum population of 50 to 500 individuals in the late summer whereas an average honey bee colony has 40,000 individuals.

In the spring it often takes the queen bumble bee until June to produce her first brood of 6 or 8 workers and thus set the stage for more rapid increase. By early August, when second-crop alfalfa is in full bloom, the colony has usually reached maximum size and vigor. At this time many drones and

new queens are produced. Soon after mating with drones, the new queens leave the colony and bury themselves for hibernation. The colony, having accomplished its mission of producing fertile queens for the following year, gradually dies out. By September brood rearing has generally ceased, and bees still seen on flowers are feeding on nectar to extend their span of life. Basic features of the bumble bee life history are summarized in table 3.

Two of the 6 species of bumble bees valuable to alfalfa in the Intermountain Area extend their ranges into the large

valleys. They usually nest above ground in outbuildings where they can find old mouse nests, mattresses, seat cushions, insulation, and similar nesting materials. Such material stuffed between studs in

Fig. 56. Early nest of a bumble bee (*Bombus morrisoni*) showing honey pot and wad of pollen containing first brood

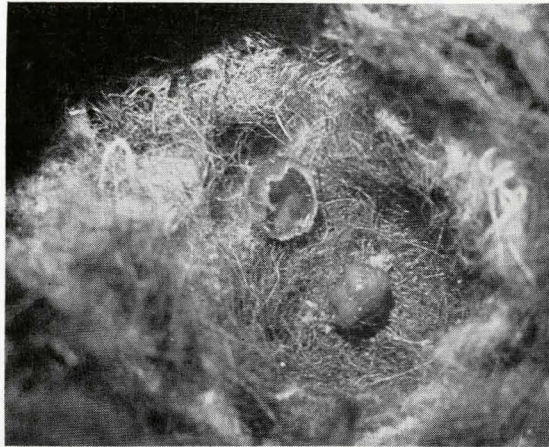


Fig. 57. Fully developed nest of a bumble bee (*Bombus morrisoni*) showing: (a) wax honey pots (b) pollen pot (c) male or worker cocoons (d) queen cocoon (e) egg basket opened to show eggs (f) patch of brood (developed from egg basket) containing young larvae (g) patch of brood with nearly full-grown larvae (h) worker bee (i) male bee (j) nesting material

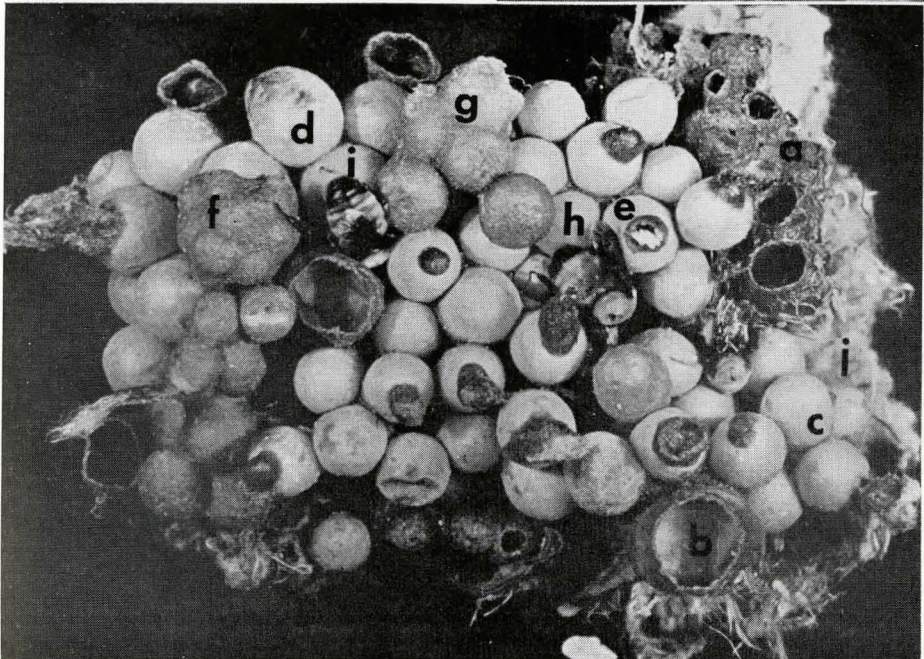


Table 3—Typical course of events in a bumble bee colony in Cache Valley, Utah

October - March	Mated queen hibernates.
April - early May	Queen emerges, seeks nesting place.
May - early June	Queen starts colony, stores nectar and pollen, lays eggs.
June	First workers produced. Queen retires to nest.
July - August	Workers available in large numbers for pollination.
September	New queens, drones produced.
	New queens mate, scatter, and seek shelter. Colony dies out.
October - March	Mated queens hibernate.

double walls should attract many queens in the spring. The other species of bumble bees nest underground, usually in rodent burrows.

As has been stated, the critical period for bumble bees is in the spring when the queen must forage alone or with the help of only a few workers. Fruit blossoms and wild currant are valuable in the early spring. A small acreage of vetch is ideal for build up until the alfalfa comes into bloom.

Insecticides can be hazardous to bumble bees. In foothill areas insecticides applied to fruit bloom can kill the foraging queens and thus destroy young colonies.

Leaf-Cutting Bees Another Important Group

Leaf-cutting bees (*Megachile* spp.) range in size from slightly smaller to slightly larger than honey bees. Females can be readily recognized by their dark gray color and the pollen packed on the underside of their bodies rather than on their legs (fig. 58). Circular and oval holes about ½ inch wide in leaves of shrubs demonstrate their presence in the area but not necessarily on alfalfa (fig. 59). The more common species collect pollen from more plants than alkali bees but not from so many as

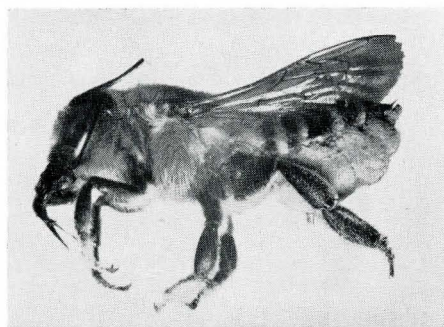


Fig. 58. A leaf cutting bee (*Megachile peribirta*) with alfalfa pollen on its abdomen

bumble bees. Legumes and composites are favored but many other common flowers such as rose and mallow are also visited. Although these host plants can be looked upon as competitors for the attentions of leaf-cutters during the blooming period of alfalfa, some of them are necessary to maintain the bees before and after this time.

Although they may be seen in nearly all alfalfa fields, more than one leaf-cutter per 50 square yards is unusual. Rarely has as many as one per 5 square yards been observed. The largest populations are most likely to be found on small fields near uncultivated areas. Considering their efficiency, even such small numbers as one per 50 square yards can aid materially in pollinating the seed crop.

Leaf-cutting bees that work alfalfa generally first appear in May and reach their greatest abundance in August. During this period there are at least two and probably three generations. The adult females utilize various kinds of nearly tubular cavities in plant stems, in wood, or in the soil in which to place rows of cells lined with leaf pieces (fig. 60). Each cell is provided with a mass of honey-moistened pollen in which an egg is embedded. About one month is required for the bees to develop from eggs to adults. The adults of the last generation remain in their leaf cells through the winter.



Fig. 59. Cottonwood foliage cut by leaf cutting bees



Fig. 60. Brood cells of a leaf cutting bee in beetle burrows in an old cottonwood log

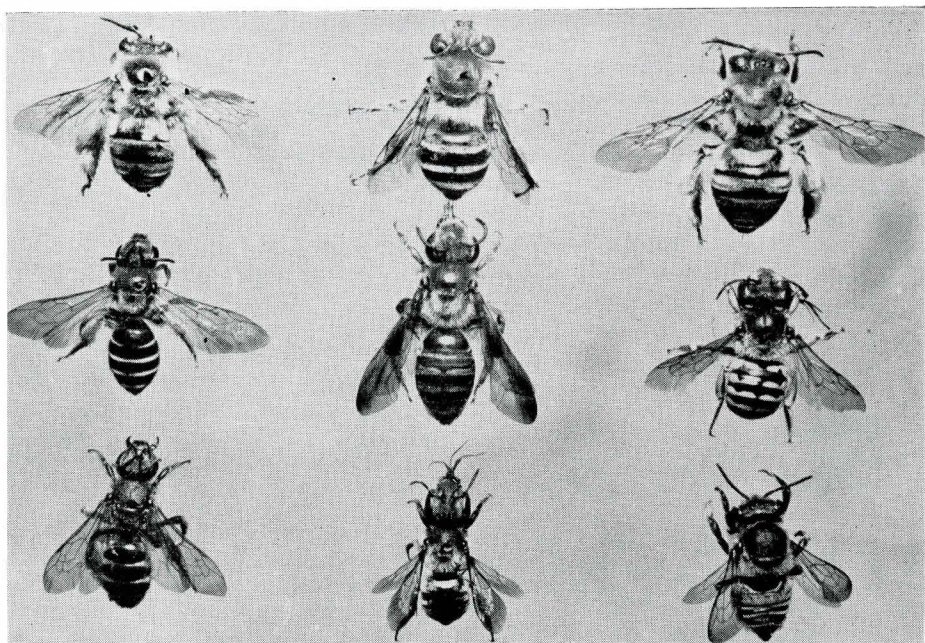


Fig. 61. Species of alfalfa pollinators in the Intermountain Region: *Melissodes* sp., *Anthophora urbana*, *Tetralonia edwardsi*, *Halictus rubicundus*, *Andrena prunorum*, *Anthidium*, sp., *Agapostemon virescens*, *Osmia seclusa*, *Megachile onobrychidis*

Leaf-cutting bees are largely solitary, and nesting preferences for most species are not adequately known. In forested regions of Canada, where most of the species nest in dead aspen, seed growers have provided nesting places by cutting and piling the aspens, but in more arid regions, where most of the species nest in the soil, no practical method for preserving or increasing their nesting sites has been developed. However, any preservation of uncultivated land should help them to survive.

Other Wild Bees May Pollinate Alfalfa in Local Areas

It is impossible in this circular to discuss separately the various other kinds of wild bees that pollinate alfalfa. However, if a seed grower is benefiting from other kinds, he would do well to have them identified on the chance that he

could get some specific information on how to encourage and protect them (fig. 61).

Wild Bees Should be Protected and Utilized

From the foregoing discussion these general measures might be taken to make the best use of wild bees.

- If useful wild bees are known to be present, time alfalfa bloom with the period of their greatest abundance.
- Plant seed alfalfa in areas where alfalfa-pollinating species are known to be abundant.
- If in isolated seed areas wild bees are setting most of the crop, don't expand your seed acreage beyond

the capacity of the bees to pollinate.

- Reduce competing sources of pollen and nectar in the area during the period your seed crop is in bloom.
- In areas supporting natural timber growth, supply nesting sites for leaf-cutting bees by cutting and piling trees (especially poplars and aspens) near the alfalfa field. The timber should be piled loosely for aeration and availability to beetles and bees.
- Search for nesting sites of alkali bees and keep them in an unaltered condition.
- If natural soil conditions and water sources permit, prepare and maintain suitable areas for alkali bees to occupy.
- If possible, provide spring and early summer bloom for build up

of bumble bees, leaf-cutting bees, and certain other species.

- Apply insecticides to blossoming plants only in accordance with recommendations in this circular.

There is Sometimes Competition Between Honey Bees and Wild Bees

Growers are often concerned about the danger of honey bees driving wild bees out of alfalfa fields. In the case of alkali bees, the reverse is apt to take place if the alkali bees are abundant. On the other hand, heavy concentrations of honey bees are known to lower the attractiveness of alfalfa fields to bumble bees and leaf-cutting bees. If your field normally attracts enough wild bees (other than alkali bees) to set a good seed crop (see section on number of bees needed), honey bees should not be increased in the area.

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